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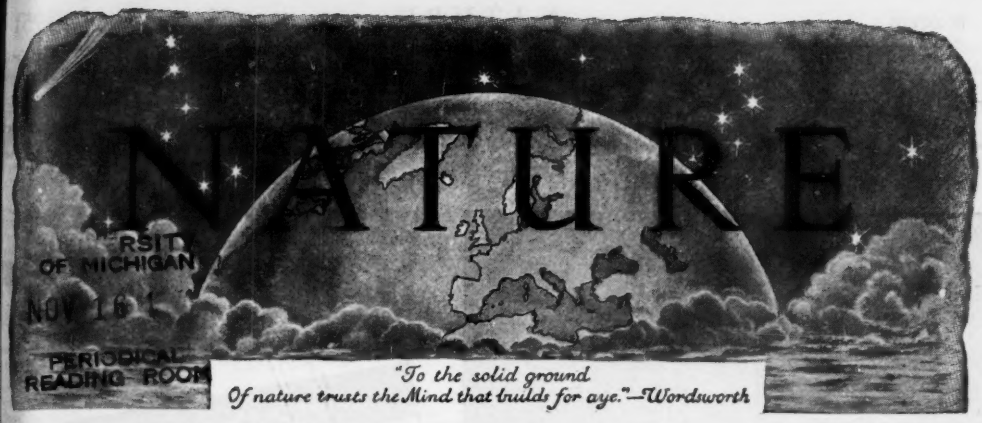

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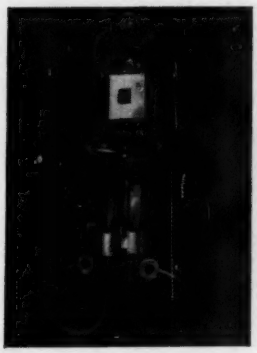

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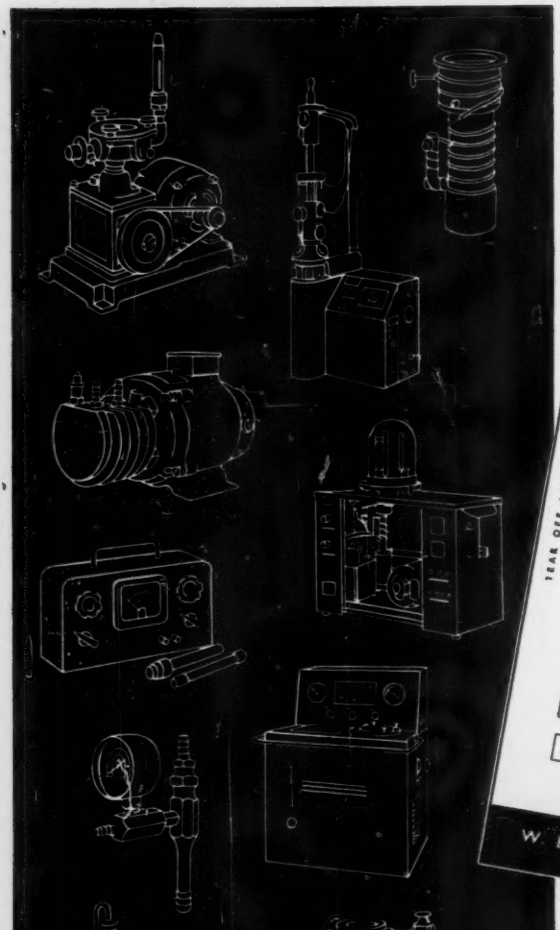

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LEADERSHIP, EDUCATION AND TECHNOLOGY

IN his lecture on August 29 on higher technical and scientific man-power in Great Britain in the series of centenary lectures on the worker in industry, arranged by the Ministry of Labour and National Service, Lord Hankey remarked that in his wide experience in peace and war the qualities of 'leadership' and 'character' are harder to find and are even more important than technical capacity. Similarly, his earlier Romanes Lecture on "The Science and Art of Government" emphasized that since government is primarily concerned with human beings, human relations and human personality are dominating considerations. Whatever measures are taken to introduce the humanities to the curriculum for students of science and technology, whether at the undergraduate stage or before entry to the university, Lord Hankey's suggestion for broadening the outlook and experience of those destined for positions of high administrative responsibility in the world of science and technology presupposes that the universities and technological institutions in which they were originally trained do, in fact, receive in the first instance a fitting proportion of the ablest minds in each generation.

In an article on "Research in the Universities" published much about the same time (*Universities Quarterly*, August), Prof. A. R. Ubbelohde expressed a similar view: except where their professional qualifications make it absolutely essential, scientific workers in Britain do not occupy public positions in proportion to their native talents. It is true that some, quite apart from any administrative qualities they may or may not possess, are indisposed to deal with administrative duties: they would endorse whole-heartedly Sir Cyril Hinshelwood's forthright declaration that the man of science is in peril of being overwhelmed by the mass of administrative work. That danger exists, and some pruning of the proliferation of committees and other administrative work within and without the academic world may well be required. There will remain, however, an irreducible minimum of administrative responsibilities, and if these are not discharged by the scientific men themselves, they must be carried out by those who can at least understand the outlook and the method of science as well as its findings. Otherwise, as Prof. Ubbelohde rightly insists, in this technological civilization very wasteful and damaging situations can arise.

During the past twenty years, the annual Walker Trust Lectures at the University of St. Andrews on leadership have dealt with various aspects of leadership—its nature, the way it is exercised in different walks of life, and above all its functioning in a democratic society. In one of the earliest of these Lectures*, Dr. J. R. Mott referred to the way in which his travels throughout the world had made him conscious of a demand the world over that the

* Walker Trust Lectures on Leadership, delivered before the University of St. Andrews, 1930–49. Pp. viii+286. (London: Oxford University Press, 1950.) 15*s.* net.

universities should equip and send forth into all walks of life more young men and women for the leadership of the constructive forces of the world; and in the latest of these Lectures (see p. 769), dealing with the universities and cultural leadership, Sir Walter Moberly urges that to educate for leadership is still a primary duty of universities, and to get such an education should be one of the chief motives which bring students to them.

Under the influence of the German ideal of the university as an institution for extending the realm of knowledge, attention has been concentrated in the modern universities of Britain on research rather than on education, and sometimes, indeed, the latter has not been clearly differentiated from instruction. Outside the ancient universities, the idea that universities are institutions for educating men and women whose abilities suggest that they may hold high positions in life was not readily accepted. Even to-day, when both ancient and modern universities are fully alive to the importance of both research and educational duties and of the interrelation of these two functions, the idea of education for leadership is unpopular in the presence of the strong equalitarian views prevalent in our society. Confused thinking on this issue has discouraged discussion of the idea of education for leadership; attention has been forced upon the subject by outspoken comments at discussions on higher technological education and at conferences organized by the universities themselves and industrial bodies such as the Federation of British Industries.

In these circumstances, Dr. Eric James's "Education and Leadership" makes a timely appearance*. It is a brief but brilliant analysis of the problem of leadership in a democratic society, and the difficulties which attend attempts at selection. Dr. James discusses in some detail the education of the brilliant individual, and in particular he deals with the contribution of the boarding school. In these chapters he raises debatable issues, but they are large issues and deserve the attention not of the educationist alone but also of the industrialist, the man of science, the politician and all who are concerned with the continuance of democratic institutions in the Welfare State.

Dr. James's first chapter, in which he discusses at length various aspects of leadership in a democratic society—the reasons for the distrust of democratic communities of the idea of an élite and the whole conception of leadership, the factors which have made leadership so important in the complex and technical situations of modern civilization and the conditions which must be satisfied for leadership to be acceptable in our society—is a fine and challenging piece of work. It is worthy of setting beside any of the lectures included in the recently published volume of Walker Trust Lectures, not excepting even those by John Buchan, Lord Moynihan, Dr. Hensley Henson, Lord Montgomery, Earl Wavell, or Sir Richard Livingstone.

* Education and Leadership. By Eric James. Pp. 112. (London: George G. Harrap and Co., Ltd., 1951.) 6s. net.

High intelligence, in Dr. James's view, is the key to the type of leadership which is competent to meet the highly complex and technical situations that confront us to-day. He does not minimize the value of character: on the contrary, he recognizes a purely materialistic view of life as more serious than the dangers of new weapons of destruction. The removal by science and technology of many material obstacles to right living imposes great demands upon spiritual leadership, because the attitude of most men to fundamental questions of moral and æsthetic judgment must depend to a very considerable degree upon the values accepted and proclaimed by a minority of exceptional individuals.

Dr. James is fully aware of the difficult problems which here confront us in our dependence for advance upon the individual, or the creative minority, at a time when authority is rejected and the validity of individual judgment accepted. He does not, however, discuss further their implications, and the way in which the dependence of effective leadership in a democratic community upon persuasion as well as upon a belief in equality of opportunity and wide diffusion has made training for leadership even more imperative. The responsible leadership which such factors, as well as the rapid development of science and technology, demand cannot be achieved, even with high intelligence, without training. These must be acquired, through common living as well as through education, mental habits of freedom, equitableness, calmness and moderation, and the power to understand men and to lead them.

In this chapter Dr. James directs attention to the social problems that are involved, once it is accepted that leadership in any field calls for recruitment of those with high intelligence. Some of our fundamental assumptions and practices will require discarding as the educational ladder is perfected and the risk of talent being unrecognized disappears. However repugnant a democratic community may feel towards the idea of special schools for leadership it must recognize, as Dr. James insists, that if society is forced to place authority and responsibility in the hands of certain individuals, education has no more urgent task than to see that those individuals are, so far as is possible, adequately prepared for their tasks.

The concern over higher technological education indicates that this point is appreciated in one sector of the field; but there is plenty of evidence to show that its general implications are by no means commonly accepted. There is a real danger that equality in education may come to mean—and not merely in the comprehensive secondary school—the limiting of opportunity for those abler children on whom the nation greatly depends. It is easy to point to instances of defective leadership in almost every sector of the national life: able leadership in the industrial or technical field can scarcely exert its full influence unless it is matched by equally wise leadership in the trade unions and in the political field. Not the least important feature which makes Dr. James's book a 'tract for the times' is its analysis of the difficulties

which in our present system attend the education of the most gifted individuals, and of the implications for to-day of the Platonic conception of education.

Dr. James is not afraid of raising debatable issues, but he shows convincingly exactly why it is important that those who are destined to become leaders in government, in science and in industry must be exposed to the influence of first-rate minds and given the opportunity of growing in an environment designed to meet their needs. We can, he remarks, legitimately demand from our leaders that they shall have devoted at least some thought to certain perennial and fundamental problems of individual and social life. Ideally, they should have arrived at a coherent philosophy and a basis of principle in the light of which they will make their judgments. Some studies are manifestly more likely than others to force young men and women to grapple with these general questions of politics and æsthetics, of morals and metaphysics, and to encourage them to submit their standards of value to constant scrutiny. In the nature of things, the young scientific worker or technologist will learn more of what is in the minds of men, the thoughts that have always excited and the enduring traditions, from history, philosophy and literature, than he can from his own subject, no matter how fine that may be as an intellectual discipline.

It can scarcely be altogether fortuitous, Dr. James points out, that the course of study most conspicuously successful in producing the highest kind of leadership is also that in which the student is bound to concern himself with the greatest questions of human conduct and social obligation. He does not deny that there are many scientific men who are at least as wise in their political and moral judgments as their colleagues who have studied the humanities. Nevertheless, it is much easier for an individual in some schools and all universities to study chemistry, for example, and never have to ask himself what he means by justice, or what are the limits of his obligation to the State, than if he had studied history or philosophy. If such an individual comes to occupy a position of authority he is to this extent less well equipped, and for that reason it may be questioned whether the policy of higher technical education which was outlined in the White Paper of September 20 will do anything to supply higher technologists of the quality really required. Still more important is the question whether a policy of entrusting such education to the technical colleges will ensure that it is carried out by teachers of sufficiently high standing. On the importance of that factor, not only Dr. James but also the majority of participants in the debate on higher technological education have insisted; and it is notable, as the recent discussion in Edinburgh showed, that even those who are most anxious to see the task entrusted to the technical colleges are doubtful whether, in fact, without a transformation of the whole structure of the technical colleges, rendering them independent of the local authorities, it will be possible to provide those conditions of academic freedom as well as of remuneration which will attract teaching staff of the requisite calibre.

Higher technological education is only one of the problems which this book illumines, and like the Walker Trust Lectures on leadership it contains much wisdom to guide us in shaping our future policy, both there and in the expansion of the universities. Vocational education is inescapable, and its extension at the universities may be unavoidable. We may be called upon to determine more carefully the nature of good vocational education, but that the universities will continue to be places of vocational education and that young men and women should seek earnestly to prepare themselves within a university for vocations to which they wish to devote their lives is, as Prof. G. B. Jeffrey emphasized in his Eddington Memorial Lecture, wholly admirable.

Nevertheless, neither the universities nor the colleges of technology can accede to all the demands now being made upon them for the provision of new forms of training without their structure and character being profoundly changed. The universities must discover some principle of decision, rooted in their own tradition, on which they can give an answer to these demands. Prof. Jeffrey suggested that this might be found by appealing to the characteristics which in his view should be the mark of a university: a temple of knowledge, one and indivisible; inspired by a social purpose, and a place in which young people are prepared in body, mind and spirit for service in other spheres. To justify vocational training in a university, a profession must therefore show that the field of knowledge requisite for its exercise is a part of the integrated body of knowledge for which the university is trustee; that this general body of knowledge would be manifestly incomplete if it failed to have regard to these professional studies; and that these professional studies could not be adequately pursued except in living contact with the greater body of knowledge. A profession that can meet this test is rightly described as a learned profession, and can further make some contribution towards giving a student a worthy conception of the great body of knowledge of which the university is itself a symbol.

That, after all, is one central point. We may presuppose that through a wise and rigorous selection the universities receive a fitting proportion of the ablest intellects of each generation. We must recognize, too, that the engineer or physicist trained in a university is marked out as a potential leader, at least in his chosen profession, and for that leadership he needs education. Part of that education must be social, and for that duty to be discharged the universities must find new forms, appropriate to our time, of giving social expression to the unity of knowledge in the fellowship of learned men. But the need still remains for liberalizing vocational education, and for ensuring that in every scientific and technological course appropriate place is found for the humane studies, with the insight they afford into the minds of men.

STRUCTURAL INORGANIC CHEMISTRY

Structural Inorganic Chemistry

By A. F. Wells. Second edition. Pp. xi+727. (Oxford : Clarendon Press ; London : Oxford University Press, 1950.) 35*s*. net.

Anorganische Strukturchemie

By Prof. W. Hückel. Pp. xv+1033. (Stuttgart : Ferdinand Enke, 1948.) 71.20 DM. (£5 10*s*. 0*d*).

Structural Chemistry of Inorganic Compounds

By Prof. Walter Hückel. Translated by Dr. L. H. Long. Vol. 1. Pp. xiii+437. (New York and Amsterdam : Elsevier Publishing Co., Inc. ; London : Cleaver-Hume Press, Ltd., 1950.) 70*s*.

IN his foreword to "Anorganische Strukturchemie" Prof. W. Hückel states that "this work attempts to furnish inorganic chemistry with that which organic chemistry has long possessed as a basis for its systematization, namely, a structural and constitutional theory in one embracing representation", while in "Structural Inorganic Chemistry" Dr. A. F. Wells has a less ambitious aim based on his conviction that the structural side of inorganic chemistry cannot be put on a sound basis until the results of X-ray crystallography and other techniques of investigating structure have been incorporated into chemistry as an integral part of that subject. With these aims the two books inevitably cover a good deal of common ground, but they differ considerably as a result of the authors' different outlooks, and this not only in content but also in the nature of the approach. In particular, whereas in general Dr. Wells is content to let the facts speak for themselves and is careful to make quite clear what are facts and what is speculation, Prof. Hückel frequently adopts the style of the advocate, and in some cases belabours those whose views do not please him with what seems to me to be unnecessary vehemence ; moreover, in reading some of Prof. Hückel's discussions, a student would find it very difficult to decide whether the examples given were based on experimental facts or merely inferences from theory.

The second edition of Dr. Wells's book follows the same general plan as the first edition, but in addition to being expanded by about 25 per cent it has been considerably improved in various respects. Part 1, consisting of six chapters dealing with such matters as covalent bonds and their properties, the crystalline state, and the experimental methods of structural chemistry, has been somewhat reduced in length, chiefly by omitting a chapter on the structure of the atom and shortening one on states of aggregation. By passing quickly over subjects on which there is already an extensive and easily accessible literature, the author has thus been able to give a much more satisfactory treatment of a number of topics to which he scarcely did justice in the first edition ; for example, a student reading the second edition can now obtain an understanding of some of the contributions of thermodynamics to structural chemistry, and when he encounters a new concept he will now find either an explanation in the text or a good reference to its more extended treatment elsewhere.

Part 2 contains a systematic description of the structures of most of the important classes of inorganic compounds. The additions to our knowledge in this field since the first edition appeared have been very great, and the formula index of the book now contains nearly twice as many entries as before. The text of Part 2 has, however, increased by less than 50 per cent, and Dr. Wells has very successfully incorporated the new matter without loss of clarity in the general treatment ; a valuable feature of the book is that bond-lengths and other data are presented critically so that, for example, the student can see clearly to what extent a particular structural theory is supported by the experimental facts.

The production of the book is of the high standard expected of the Clarendon Press, and I have not noticed any misprints. The price has increased only in proportion to the size and still remains remarkably low, particularly having regard to the wealth of excellent illustrations which the book contains. The provision of numerous references to the original literature in the form of footnotes is a considerable improvement, and the two indexes (formula and subject) are adequate, although those who, like myself, take a minor delight in the eponymic nomenclature of inorganic chemistry will note with regret that old friends such as Fremy's and Reiset's salts are not allowed to appear in the subject index but must take their places with the common herd in the formula index.

In retrospect I feel that in devoting a large part of my review of the first edition of Dr. Wells's book (see *Nature*, **157**, 386 ; 1946) to remarks on some of its shortcomings, I did less than justice to its positive merits ; in acknowledging this, it is a pleasure to express the opinion that the second edition retains all the merits of the first and scarcely any features which could be described as defects even by the most exacting critic.

A great many people would wish Prof. Hückel success in his attempt to provide a single all-embracing structural and constitutional theory for inorganic chemistry, not least those numerous students who go up to universities with a disinclination for inorganic chemistry because "it isn't systematic like organic chemistry", and it is therefore of some interest to inquire whether Prof. Hückel's book is likely to appeal to such students. It should perhaps first be asked whether it is intended to do so, and the answer to this is not easy to find. The author explains that he wrote various parts of the book at different times as monographs, in part at least to familiarize himself with the topics concerned, and this, together with his obvious conviction of the value of his method of approach for the development of the subject, suggests that the book is addressed to mature workers in chemistry. In assembling the parts into the finished book, however, additional matter seems to have been added to make the work suitable as a text-book. The result is a most interesting and unconventional book, but not in my opinion a successful one ; indeed, to embark on a task such as Prof. Hückel has attempted requires a belief in an inherent simplicity in Nature which, if it exists, is at present obscured by too many hard facts.

Prof. Hückel takes the view that while the Periodic System probably gives as good a basis as any for the classification of inorganic substances for elementary study, classification based on bond types is better for the advanced worker ; and he believes further that the Werner co-ordination theory, which is valid for a high proportion of inorganic compounds, should be given much more prominence in this classification. This view underlies the plan of the book and the

development of most of the themes in it, and, while the resulting treatment has much to commend it (and indeed in many respects is not so novel as Prof. Hückel seems to think), it is pursued too exclusively, so that the book as a whole is unbalanced. Thus while the author concedes that kinetic and thermodynamic studies have much to contribute to inorganic chemistry, he devotes relatively little space to such matters (entropy is not mentioned), and when he warms to his theme he is apt to deny virtue to anything but stereochemistry. Apart from the lack of balance in treating existing knowledge, such an attitude may have the unfortunate consequence of persuading its holder that the main object of future work is to provide confirmation for a theory.

The work is divided into three books: (1) stoichiometry and systematization, (2) atomic structure and chemical bonding, and (3) structure and constitution. Book 1 opens with a good historical survey and then discusses the basis of systematization—the co-ordination theory, valency and bond types, and Werner's work. It concludes with a chapter of about 140 pages on complex compounds in which the author illustrates the application of the co-ordination theory to double salts, salt hydrates, inner-complex compounds, multinuclear compounds, polyacids, etc. Book 2 deals with the Periodic System, atomic structure, methods of investigating bonding, and the nature of the chemical bond. This section is very unbalanced and very uneven in quality; for example, in the chapter on methods fifteen pages are devoted to molecular volumes and only two to electron diffraction, and the account of several of the methods is neither sufficiently clear to be suitable for a student nor critical enough to be useful to an advanced worker. Book 3 contains chapters on inorganic molecules and volatility, crystal chemistry, silicates and glasses, metals and alloys, and chemical reactions. These chapters contain a wealth of material and make very interesting reading, but they contain more errors than one would expect, some merely irritating and others definitely misleading.

A student taking up this work will find much that is interesting, although not much that he cannot find elsewhere; he will almost certainly not feel that the new approach offered him is appreciably more systematic than that which he has known previously—the canvas is too vast and the book attempts too much. Some advanced readers may find the treatment attractive, but it does not make the book particularly easy to use as a work of reference, even with the help of the excellent indexes; the style is frequently turgid and too often inclined to be polemical (of five references to a well-known pre-war text-book, four are made in order to criticize).

The first volume of Dr. L. H. Long's "Structural Chemistry of Inorganic Compounds" contains Books 1 and 2 of Prof. Hückel's work, and it is unfortunately necessary to say that it is a very bad translation. A rather large number of misprints mar an otherwise beautifully produced book; but, in addition, many errors have been introduced by the translator (as, for example, "more frequently" for "vielmehr", making nonsense of the sentence in which it appears). Dr. Long explains in his foreword that the unusual complexity of the original language has given him difficulties; but a translator can scarcely be regarded as discharging his task adequately when he gives an almost word-for-word translation of a difficult German sentence to produce such a monstrosity as "The force of affinity was supposed to exhibit itself between dissimilar particles as, for example, the reaction between acid and base teaches". Still less can he be excused for mis translating the German into such sentences as "This fact is expressed here by the nature of the opposing forces in the representation selected for the maintenance of stable structural arrangements through the equilibrium of forces". These examples are among the worst I have encountered; but on nearly every page there is some clumsy construction, error of translation or misprint, with an occasional grammatical error or spelling mistake, so that the book makes very irritating reading.

E. G. Cox

MAN IN BRITAIN THROUGHOUT THE AGES

A Natural History of Man in Britain

Conceived as a Study of Changing Relations between Men and Environments. By H. J. Fleure. (New Naturalist Series.) Pp. xviii+350+64 plates. (London and Glasgow: Wm. Collins, Sons and Co., Ltd., 1951.) 21*s*. net.

IT need scarcely be said that anything Prof. H. J. Fleure writes is worth reading. The book is clearly not intended for the specialist, as its range both in time and subject-matter is enormous; but it will doubtless appeal to schools and the general public interested in the study of man throughout the ages in the British environment.

More than half the available space is taken up with a history of England from the Stone Ages until modern times, and, as this half consists of only 181 pages, even Prof. Fleure's excellent summary can but be in the nature of a sketch. On the other hand, the next chapter, which deals with people and their racial make-up, is a first-class piece of original work, the result of long years of research undertaken with the help of the Leverhulme Trust. A chapter on clothes throughout the ages, and others on dwellings, villages and towns follow. The one on dwellings, especially, contains much general information on early types of habitation. There follows a chapter on the church and the castle, concerned not only with architecture but also with religious and lay organizations throughout the period. The book concludes with a brief account of the changes in means of transport and the alterations and rises in population in the countryside and towns. As has been said, whatever Prof. Fleure writes is interesting; but it is rather sad that only in Chapter 9 does opportunity occur for him to give an account of his original researches in a subject of which he is an acknowledged master.

There are numerous excellent photographic illustrations, thirty-eight of them in colour. Frankly, the latter are the less satisfactory. The colours are not too good, and the subjects in many cases irrelevant. It is difficult to see why a colour plate should have been devoted to a Highlander teaching a boy to play the pipes; nor can one be very excited about a small farm-house near Snowdon merely because it is entitled, "House of a man who married a fairy"—neither have much relevance to the text. The half-tone illustrations are better chosen and well reproduced and include some really lovely photographs. The line-drawings of such objects as stone implements are entirely inadequate. This is to be

regretted, as one such sketch figures the chalk idol found many years ago by Mr. Leslie Armstrong at Grimes Graves and which I fancy has never up to now been illustrated. One gets the unfortunate impression that the illustrations have been included rather to catch the eye of a would-be purchaser than to illustrate the text. The book is very readable, and one can be full of admiration for Prof. Fleure, who certainly set himself a difficult task.

M. C. Burkitt

THEORIES OF THE VISUAL THRESHOLD

Les théories photochimiques classiques et quantiques de la vision et l'inhibition nerveuse en vision liminaire

Par Ernest Baumgardt. Pp. 61. (Paris : Éditions de la *Revue d'Optique théorique et instrumentale*, 1950.) 300 francs.

SINCE the pioneer work of Hecht, Shlaer and Pirenne on the significant part played by the quantum nature of light in the perception of threshold light stimuli, a number of workers, including the author of this little book, have applied themselves enthusiastically to the full exploitation of the idea. M. Ernest Baumgardt belongs to those who believe that *two* or more light quants must be absorbed within a certain small time-interval and within a certain retinal area if perception of the stimulus is to ensue. The experimental results which it is sought to explain on this hypothesis consist of measurements of the absolute threshold as a function of the exposure time and the area of the test stimulus. The second half of the book is, in fact, devoted to new measurements of this kind by the author, dealing in the main with the effect of stimulus area for both foveal and extrafoveal vision and employing blue and deep-red stimuli to separate the rod and cone responses.

So far as the variation of threshold with exposure time is concerned, the central hypothesis is not entirely adequate, the deviations being in the direction one might expect if the minimum number of quantum absorptions for perception exceeded two. The author is able to show, however, that a possible explanation is obtained on the following lines. The neurone receiving the pulses from the receptors which have absorbed light quants is assumed to be thrown into a state of facilitation following the absorption of the first light quant. This lasts for a critical time τ, and if within this time a second quant is absorbed the neurone discharges and perception ensues. But if the second absorption is delayed beyond the time τ, the neurone passes into a refractory state and, even though a third quant may be absorbed within a time τ after the second, there is no discharge and no perception. For extrafoveal vision the effect of area on the threshold is found to accord well with the central hypothesis, the critical area corresponding to about 45′ diameter for rod vision and 8′ diameter for cone vision. For foveal vision the situation is complicated by the inhomogeneity of the receptor network. It is remarkable—and this criticism applies not only to the present work—that investigators of areal summation rarely make any attempt to explore the uniformity of the threshold over the retinal region under study by point-to-point observations with a small test stimulus.

Some interesting comments are made by M. Baumgardt on the notion that as the level of adaptation of the retina is raised the progressive modification of visual functions such as differential sensitivity is associated with a steady reduction in the concentration of photosensitive substance (visual purple for rod vision) in the end-organs. He vehemently rejects this view, at least for levels up to about one lumen per square metre. While we may not be prepared to go all the way with him, his arguments seem worthy of careful consideration. Unfortunately the style in which the book is written is a little repelling : it tends to oscillate between the dogmatic and the obscure. This is a pity, as M. Baumgardt's views should prove stimulating to all workers in the subject.

W. S. Stiles

FUNCTION THEORY

Leçons sur la théorie des fonctions

Par Émile Borel. (Collection de monographies sur la théorie des fonctions.) Quatrième édition. Pp. xiii+296. (Paris : Libr. Gauthier-Villars, 1950.) 1200 francs.

Leçon. sur les nombres transfinis

Par Prof. Waclaw Sierpiński. (Collection de monographies sur la théorie des fonctions.) Nouveau tirage. Pp. 240. (Paris : Libr. Gauthier-Villars, 1950.) n.p.

THE great collection of monographs on the theory of functions, directed by Émile Borel, was inaugurated in 1898 by his own "Théorie des fonctions", of which the present work is a fourth edition. Although the substance of the book has not changed much, and is therefore more than fifty years old, it is still perhaps the most inspiring introduction for the young student to the concepts of aggregates, measure and modern theories of integration, concepts the development of which can be traced back to the stimulus of Cantor's work on "Mengenlehre". The new edition contains some additional matter in notes and in a new appendix, all tending to emphasize Borel's own philosophical position with respect to current controversies on the foundations of mathematics.

Borel has always held the view that definitions which are not constructive, numbers which cannot be calculated, descriptions which do not define, are insecure pillars in a mathematical edifice, though his scepticism is not carried to the extreme position occupied by Brouwer and his school. If, as he says, the result is that the pupils of his pupils regard him as a reactionary, it is because his own work and teaching have been extraordinarily stimulating.

The reprint of Prof. W. Sierpiński's tract on transfinite numbers in the Borel collection is welcome. The author was the acknowledged master of the virile Polish school of real-variable theory, and his account of the transfinite cardinals and ordinals is clear, precise and succinct. While Sierpiński's main logical position is almost flatly opposed to Borel's, the series of Borel monographs would have been sadly incomplete without some account of Cantor's fundamental work on transfinite numbers, and no one was better fitted than Sierpiński to write such an account. Since the techniques employed are in themselves not of great complication, the book can be read and enjoyed, without much previous acquaintance with the topic, by anyone with a taste for fantastic logical adventures of a severely abstract type.

ALCHEMY AND ALCHEMISTS*

By Prof. JOHN READ, F.R.S.

The Nature of Alchemy

MOST people who think about alchemy in the present age (and there are not many who do) regard it as the pretended art of transmuting base metals, such as lead, into the noble ones, silver and gold. Liebig held the view that alchemy was never anything else but chemistry; from this point of view one may look upon alchemy as the chemistry of the Middle Ages. In its widest and truest significance, however, alchemy was a grandiose philosophical system which aimed at penetrating the mysteries of creation and of life; it sought to place the microcosm of man in adjustment with the macrocosm of the universe; the transmutation of one form of inanimate matter into another was merely an incidental alchemical goal.

The more one studies alchemy, the more complex it appears. It was, indeed, a vast network of rudimentary chemistry, interwoven with philosophy, astrology, mysticism, theosophy, magic, and many other strands. The associations of alchemy with religion and with psychology still offer wide fields of study; in recent years C. G. Jung, in particular, has expressed the opinion that alchemy is no less important to psychology than to chemistry.

Alchemy endured for more than a millennium, that is to say, from at least early Christian times until the end of the seventeenth century. But alchemy has long been outmoded, and so there is little realization at the present day of the extent to which alchemical conceptions and imagery permeated the thought and art of the Middle Ages.

Sketched in broad outline, the fundamental ideas of alchemy were, first, that all forms of matter are one in origin; secondly, that these forms are produced by evolutionary processes; thirdly, that matter has a common soul which alone is permanent: the body, or outward form, being merely a mode of manifestation of the soul, is transitory and may be transmuted. Here are views which in their essentials bear a remarkable resemblance to those of modern physical science. Indeed, in this twentieth century "modern alchemy", as Lord Rutherford called it, has shown the possibility of bringing about many transmutations of elements.

Alchemical reasoning was mainly deductive and based on two *a priori* assumptions: first, the unity of matter; secondly, the existence of a potent transmuting agent, known as the Philosopher's Stone. From the postulate of the unity of matter it followed that this medicine of the metals became also the medicine of man. In this guise the Philosopher's Stone was known as the *Elixir Vitæ*, or Elixir of Life.

From this summary it should be clear that alchemy was much more than an experimental science. It was a philosophical system. In their true significance, the efforts made by the adepts to transmute metals were attempts to prove the truth of the broad philosophical system of alchemy by means of material experiments.

* Substance of a discourse delivered on August 10 to the British Association for the Advancement of Science meeting at Edinburgh.

Origin of Alchemy

The universal patron adopted by the alchemists from early times and throughout the Middle Ages was Hermes Trismegistos, or Hermes the Thrice-Great. In this Greek equivalent of the Egyptian Thoth, the deified intellect, the alchemical fraternity recognized the father of the Hermetic Art and the author of the Emerald Table. The thirteen precepts of this Table formed the articles of association of the so-called "Sons of Hermes": it laid down in cryptic language the guiding principles of their creed.

Thoth, as depicted in ancient Egyptian temples, was sometimes shown with the *crux ansata* (the symbol of life) in the right hand, and a staff in the left. Linked with the staff were a serpent, a scorpion, a hawk's head, a circle, and an asp. Each of these representations had its particular symbolical meaning. Such symbolism was later characteristic of alchemy; and even modern chemistry, the daughter of alchemy, is to a large extent a science of symbols.

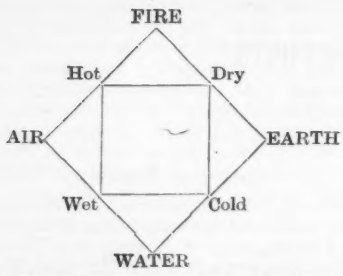
The origin of alchemy has often been ascribed to Egypt, otherwise known as Khem, the Biblical Land of Ham. Sometimes it has been supposed that alchemy arose farther to the east, in Chaldea, or even in China. The Chaldeans, as exponents of astrology, associated the sun, moon and planets with specific metals, and also with human organs and destinies. Still farther east, in ancient China, alchemical ideas may be traced as early as the fifth century B.C. in the comprehensive religious and philosophical system known as Taoism. Much later, in the first century A.D., Wei Po-Yang, "the father of Chinese alchemy", wrote the first treatise in Chinese dealing with alchemy, in which he described the preparation of the "pill of immortality", otherwise the *Elixir Vitæ*.

The ultimate origin of alchemy is thus a vexed question. There is little doubt, however, that alchemical knowledge and ideas were gathered from the ancient civilizations of Egypt, Babylonia, India, and China, and brought to a focus in Greece. From Greece this corpus of alchemy was transmitted to Islam, mainly through Syria and Persia. Eventually the accumulated knowledge of the Muslim alchemists, drawn from these various sources and augmented in its passage through Islam, was brought into Western Europe, chiefly through Spain.

Alchemical Theory

Alchemy, like modern science, had its guiding theoretical principles. The fundamental theory of alchemy was that of the Four Qualities and Four Elements, often represented in a diagram formed of an outer and an inner square (see p. 760).

The corners of the outer square carry the names of the four elements: fire, earth, water and air. The corners of the inner square, situated at the mid-points of the sides of the outer square, are allocated to the four fundamental qualities: the hot, the dry, the cold, and the wet. The diagram shows that fire is hot and dry; earth, dry and cold; water, cold and wet; air, wet and hot. These four elements may



The four qualities and the four elements

also be looked upon as representing energy (fire) and the solid, liquid and gaseous states of aggregation of matter (earth, water, air).

This theory, usually ascribed to Aristotle, may be traced in Egypt and India as far back as 1500 B.C. It is the oldest theory of physical science, and it was very widely held, in one form or another, over a long period. It bears out the statement that "there is a great oneness in the human mind in the matter of broad principle in crude cosmical ideas".

According to the theory, water—one of the four elements of the material world—is an embodiment of cold and wet qualities. When the cold quality is replaced by the hot one, the element water is changed into the element air, embodying the wet and hot qualities. The idea of transmutation is thus implicit in the theory. Nowadays, of course, this process is viewed simply as a change of liquid water through the agency of heat into the gaseous form of the same substance, and there is no question of transmutation.

In essence, this ancient theory is based upon a primitive mode of thinking sometimes known as the Doctrine of the Two Contraries. This is dependent upon the recognition of a distinction between opposites, such as cold and hot, dry and wet. An apposition of outstanding importance in alchemy was that of the two opposed, or contrary, elements—fire and water. These two opposites came to light in a new guise in the sulphur–mercury theory of the metals, which seems to have been propounded by the Muslim alchemists in the ninth century A.D.

The principle here known as "sulphur" was essentially an embodiment of combustibility, and "mercury" denoted the mineral spirit of metals and also liquidity or fusibility. It was held that when these two natural principles, engendered in the bowels of the earth, came together in a state of purity the result was gold; if they were slightly impure they gave silver; if they were markedly impure they furnished only the baser metals. Beyond this, it was supposed that in states of superfine purity they could give rise to something so much purer than ordinary gold that a small amount of this product (the Philosopher's Stone) would be able to transmute a very large quantity of a base metal into gold of ordinary purity.

The chief experimental task of the alchemical adept was to imitate, and even surpass, Nature in accomplishing such changes.

In the cryptic expression and symbolic representation of alchemy, sophic sulphur and sophic mercury (as the two principles were often called) assumed many forms. For example, they were known as Osiris and Isis, sun and moon, Sol and Luna, brother and sister, masculine and feminine, active and passive, giver and receiver, fixed and volatile, wingless lion and winged lioness, and so forth.

It was supposed by the esoteric alchemists, or adepts, that the pure "seeds" of gold and silver (or quicksilver) could be extracted from these metals in the form of sophic sulphur and sophic mercury. These "seeds" could then be combined, often in a liquid menstruum, to yield the Philosopher's Stone. The succession of processes here concerned was known as the Great Work, leading to the preparation of the Philosopher's Stone, or Grand Magisterium. The Stone, resulting from the union of masculine and feminine principles, was often symbolized as an infant.

According to these views, in order to prepare the Philosopher's Stone an initial quantity of gold was necessary. The Stone (often described as a red powder) could then be used to convert base metals into more gold, so that the original gold was "multiplied", as the alchemists used to say. One of their favourite metals for "multiplication" was mercury, and this choice has been curiously vindicated by modern observations that gold can indeed be produced by transmutation from mercury, although only in excessively minute amounts and at great cost.

In modern parlance it would be correct to call the Philosopher's Stone a catalyst. Here again the alchemists are vindicated; for what more potent catalyst could be imagined than the neutrons which start and maintain the explosive disintegration of uranium-235 into other elements? "Every thing possible to be believ'd," wrote the English poet and mystic, William Blake, "is an image of truth. . . . What is now proved was once only imagin'd."

Alchemical literature abounds in cryptic descriptions and pictorial representations of the blending of sophic sulphur and sophic mercury in the synthesis of the Stone. For example, a wingless lion and winged lioness are shown in playful conflict, with a watery background (representing the liquid menstruum, or Hermetic Stream); an alchemist is depicted in the act of balancing equal weights of fire and water; the Hermetic Androgyne—half man, half woman—stands above a dragon, signifying the menstruum.

Incidents from the Bible and from classical mythology were also freely adapted to alchemical ends. Thus, in an illustrated manuscript in the St. Andrews collection, the birth of Eve from Adam's rib, with the Serpent as onlooker, is depicted to symbolize the same fundamental idea as the Hermetic Androgyne. As an example of another kind, taken from a different source, Apollo and Artemis, with the terrorizing serpent of Juno, are selected from classical mythology in order to furnish a further pictorial illustration of the same conception. Some alchemists went so far as to insist that the whole corpus of classical mythology was nothing more than a complex medium designed expressly to record alchemical truths in concealed allegories and "abstract riddles of our Stone", as Ben Jonson phrased it in his play, "The Alchemist" (1612).

Alchemical Symbolism

Pictorial symbolism is an ingredient of the first importance in alchemy. Many of the designs were characterized by colour schemes suggestive of heraldry. Among medieval examples, the so-called "figures of Abraham the Jew", dating from the early years of the fifteenth century, were held in great reverence by alchemists of succeeding ages. These figures were ascribed to Nicolas Flamel, a Parisian alchemist of

great repute; they took the form of a series of elaborate frescoes, decorating the arcade of the churchyard of the Innocents in Paris. The designs, executed in colour, were capable of a dual alchemical and religious interpretation. The Biblical story of the massacre of the innocents by King Herod formed a central feature of the series. Herod was pictured as "a King with a great Fauchion". Mothers were shown in the act of weeping "at the feet of the unpittiful Souldiers; the bloud of which Infants was put in a great vessel, wherein the Sun and Moon came to bathe themselves". In other words, infants' blood was merely a cryptic representation of the liquid menstruum which was supposed to aid in the conjunction of sophic sulphur and sophic mercury.

As another example, an illustration entitled the "First Key of Basil Valentine" (*c.* 1600) shows a king and queen as the central feature. Below the king a wolf leaps over a heated crucible, and near the queen an old man with a wooden leg manipulates a scythe around a cupel. An accompanying "explanation" directs the operator: "Take a fierce grey Wolf. Cast to him the body of the King, and when he has devoured it, burn him entirely to ashes in a great fire. By this process the King will be liberated; and when it has been performed thrice the Lion has overcome the Wolf, who will find nothing more to devour in him. Thus our body has been made fit for the first stage of our Work."

The alchemical wolf, *lupus metallorum*, was "antimony" (stibnite, or native antimony sulphide), used in the heated crucible as an agent for purifying gold, since it "devoured" traces of metallic impurities. The wooden-legged ancient signified Saturn, that is to say, either the slow-moving planet of that name or the dull, heavy metal, lead. The scythe, like other sharp implements, symbolized fire. This part of the design therefore represents the cupellation of argentiferous lead, furnishing pure silver. In brief, the First Key of Basilius shows how to begin the preparation of sophic sulphur and sophic mercury, in readiness for the next operation of the Great Work.

Probably the finest artistic examples of the avowed symbolism of alchemy are the beautiful copper-engravings of Johannes Theodorus de Bry and his associates; these occur notably in various alchemical works of Count Michael Maier, such as "Atalanta Fugiens" and "Symbola Aureæ Mensæ", published at Oppenheim and Frankfurt during 1617–18. These plates are boldly engraved: textures are conveyed by different systems of shading; human figures are drawn forcefully and correctly; the compositions have an effect of brilliance and solidity, enhanced by strong modelling and shadows.

Apart from such *ad hoc* pictorial representations of alchemical tenets, a strong alchemical influence pervaded much of the art of the Middle Ages. It found expression repeatedly in the painting, decorative architecture, sculpture and coloured glass of this era. Alchemical ideas and symbolism may be traced in detail, for example, in the work of such artists as Dürer, Cranach, Giorgione and Campagnola. It may even be claimed that every detail in Dürer's masterpiece of engraving, "Melencolia" (1514), is capable of an alchemical interpretation: the doctrine of melancholy is inseparably bound up with the Saturn mysticism which permeates alchemy[1].

Decline of Alchemy

The outstanding practical aim of alchemy until the sixteenth century was the transmutation of base metals into gold, whether from purely philosophical or mercenary motives. Early in the sixteenth century Paracelsus endeavoured to give a new direction to operative alchemy by insisting that its main goal should be the healing of disease rather than the making of gold. He envisaged alchemy as a handmaid of medicine, to be applied in the preparation of chemical remedies of mineral origin. He sought to liberate medicine from the obsession of the ancient Galenic order, and in this sense he takes rank beside such contemporaries as Luther, Copernicus and Columbus as an emancipator of mankind from the trammels of authority. The ensuing period of iatro-chemistry or medico-chemistry, lasting until the eighteenth century, witnessed a slow decline of the old alchemy.

Paracelsus was essentially a reformer and propagandist of the Renaissance. His chief contribution to alchemy was his modification of the sulphur–mercury theory by the introduction of a third principle which he named salt. In his system of the *tria prima*, or three hypostatical principles, sulphur, mercury and salt stood materially for inflammability, metallicity and uninflammability (fixidity) and mystically for the soul, spirit and body of man. The second half of the seventeenth century found both the old alchemy and iatro-chemistry on the wane. Despite their excesses, both the alchemists and the iatro-chemists had done a great deal to accumulate chemical knowledge and to prepare the way for the incipient science of chemistry which was to arise in the second half of the eighteenth century.

It is sometimes held that the publication of "The Sceptical Chymist" by Robert Boyle in 1661 heralded the end of alchemy. It is true that Boyle dismissed to his own satisfaction in this famous book the systems of the four elements and the *tria prima* and put forward the modern idea of an element; but the emergence of modern chemistry had to wait for more than another century. "During this Indian summer of alchemy the stage was held by the Theory of Phlogiston, while the four elements and the three hypostatical principles hovered behind the scenes like ghosts reluctant to be laid. Phlogiston, an imagined inflammable principle present in all combustible bodies, was essentially a revival of sophic sulphur, claiming noble descent from the Sun god of the primitive religions. Phlogiston melted finally 'into air, into thin air' with the discovery, in the second half of the eighteenth century, of the chemical composition of the ancient 'elements' air and water and of the true nature of combustion. These discoveries ushered in the era of modern chemistry."[2]

Types of Alchemists

The term 'alchemist' has been used throughout the ages to denote men, of many kinds, with a real or professed knowledge of alchemy. These ranged from impostors and charlatans having no claim to the title, through puffers (*souffleurs*), goldmakers, skilled practicants, and scholastic philosophers, to adepts and religious mystics.

Simon Forman (d. 1611), the original of Ben Jonson's alchemist, Subtle, was a typical charlatan, gaining a livelihood by imposture and having a mere smattering of alchemical knowledge. The puffers—so called from their unintelligent addiction to the bellows—were uninformed "labourers in the fire", exoteric exponents of alchemy who were animated solely by avarice: their number was legion. Some

of the goldmakers were indistinguishable from the puffers; but others, possessing a definite grasp of the principles of alchemy, occupied a higher position in the alchemical hierarchy. Goldmakers were often attached to courts and subsidized by princely patrons. One of the most picturesque of this kind was Damian, alchemist to James IV of Scotland, and Abbot of Tungland in Galloway. Damian, who is said to have been a Lombard, varied his alchemical experiments in Stirling Castle by undertaking one of the earliest experiments in artificial flight, with the aid of a pair of wings made of feathers. He took off in September 1507 from the lofty battlements of Stirling Castle; but, according to a contemporary account, "shortlie he fell to the ground and brak [broke] his thee bane [thigh bone]". In the true alchemical manner he attributed this result to the substitution, in his wings, of eagle's feathers by hen's feathers, "which yearned and coveted the mydding [dunghill] and not the skyis [skies]".

Scotland figures a good deal in the history of alchemy. Also in Scotland there are some outstanding collections of alchemical literature, particularly the Ferguson and James Young Collections in Glasgow, and others in St. Andrews, Edinburgh and Aberdeen. A century after Damian's exploit, Scotland produced a mysterious itinerant goldmaker in the person of Alexander Seton, otherwise known as "The Cosmopolite". He has also been called "the chief martyr of alchemy"; for his dramatic career is said to have ended in tragedy at Cracow in 1604, as a result of his experiences in the torture-chamber of the Elector of Saxony at Dresden[3].

The numerous paintings of alchemists and alchemical interiors, notably by Brueghel, Stradanus, Teniers, Steen, Wijck and other artists of the Low Countries, are mainly concerned with alchemists of the kinds that have been mentioned[4]. Such genre representations of these painters and of artists in Italy, Spain, Germany and other countries, are of great interest and value to historical science.

Alchemists of a severely practical type, who were interested chiefly in chemical phenomena and in the discovery and application of new substances and processes, are typified by such men as Brunschwick, Agricola, Libavius and Glauber; the scholastic philosophers by Roger Bacon and Albertus Magnus; and the religious mystics, who viewed alchemy as "the Divine Art", by Ripley and Khunrath.

Alchemical Music

Among the mystical alchemists, Count Michael Maier calls for special mention. He was physician, private secretary, and alchemist to the Emperor Rudolph II (the so-called "German Hermes") at Prague, early in the seventeenth century. A man of many accomplishments, Maier was also a philosopher, mystic, classical scholar and musician. He was a voluminous writer of great credulity, and he carried to extremes the alchemical interpretation of Egyptian and classical mythology. This subject forms the chief theme of his "Atalanta Fugiens" (1618), a quaint and fascinating work handsomely embellished with fifty copper-engravings by de Bry and his school. Each engraving is provided with a cryptic title and a Latin epigram written in elegiac couplets. Each epigram is set to music, in the form of so-called "fugues", which are in reality canons in two parts against a repeated *canto fermo*. In allusion to the classical legend, these three parts are termed, "Atalanta, or the fleeing voice", "Hippomenes, or the pursuing voice", and "The apple in the path, or the delaying voice".

Presumably, in view of the alchemical belief in the beneficent influence of music, the final processes of the Great Work, carried out in the sealed Vessel of Hermes and directed by prayer as well as by chemical and astrological influences, were sometimes undertaken to the accompaniment of musical chants or incantations. To the religious mystics among the alchemists these processes would partake of the nature of a religious ritual, and it would be natural for them to introduce music from one of these closely related activities to the other. It must be emphasized also that alchemical theories and ideas came largely from ancient Greece, and that the alchemists followed Pythagoras and Plato in ascribing a particular importance to number and harmony in the interpretation of Nature and the universe.

In 1935, some of these alchemical canons[5] were sung in public for the first time by members of the St. Andrews University choir, at the Royal Institution in London. Fuga XVIII may be mentioned as typical. The Latin epigram begins:

Si quod agens fuerit naturæ, mittit in orbem
Vires atque suas multiplicare cupit . . .

"Whatever active principle there is in nature, it sends out its force in all directions and loves to multiply the same." It is of interest that some manuscript notes of "Atalanta Fugiens" made by Sir Isaac Newton, and now in the St. Andrews collection, bear a special mark of emphasis beside this particular epigram.

References

The numbered references given above may be found in various works by the writer of the present script, as follows:

[1] For a detailed alchemical interpretation of Dürer's "Melencolia" see "The Alchemist in Life, Literature and Art", 57–62 (London and Edinburgh, 1947).

[2] *Op. cit.*, pp. 8–9.

[3] A detailed account of Seton, and of his rescuer and successor, Sendivogius, is given in "Humour and Humanism in Chemistry", 37–65 (London, 1947). The same work also deals fully with James IV and Damian (pp. 16–36).

[4] Alchemical paintings by artists of the Low Countries and others are reproduced in the work mentioned under (1) above.

[5] Some of Maier's alchemical music is reproduced in "Prelude to Chemistry" (London, 1936; 2nd edit., 1939; and New York, 1937).

A METHOD OF MAKING VISIBLE THE DISTRIBUTION OF ACTIVITY IN A SOURCE OF IONIZING RADIATION

By Prof. W. V. MAYNEORD, R. C. TURNER, S. P. NEWBERY and H. J. HODT

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FROM the medical point of view, probably the most important physical question in relation to the use of radioactive isotopes is finding their distribution in the body. If we are interested in diagnostic applications, then clearly this is the main problem which faces us. What we want to know is where the material goes, how quickly it gets there, and generally what is its natural history. If we are interested in the therapeutic use of radioactive isotopes, then the problem has a double significance inasmuch as the spatial distribution of the material is also the basis of the radiation dosimetry. The only method of defining uniquely the distribution of the material is

to use measuring or detecting systems with strongly marked directional properties. The usual procedure of taking an insufficiently protected Geiger counter with a wide aperture is quite inadequate for deducing the precise distribution of radioactive material.

In a recent publication, Mayneord and Belcher[1] have described how a scintillation counter may be used in the examination of various simple sources, and have verified the theory that such a directional system measures approximately the 'thickness' of radioactive material. In many instances we do not require, however, an accurate determination of the distribution of radioactive material, but we do require to know its approximate position and extent. It would, in these instances, be a great convenience if, instead of having to make multiple observations with a Geiger counter, draw 'equinumeral surfaces' and so deduce radiation distribution, we could obtain a visual image of the distribution of material. With such ideas in mind about six months ago, we started to construct apparatus in an attempt to form such visual images.

Apparatus

Imagine a detector in a well-canalized system receiving radiation from only a small angular region, and moving in front of a source so as to scan it. Then the instantaneous counting-rate at any moment will be proportional *inter alia* to the radioactive material 'seen' at that moment. If now we produce on a screen a brightness proportional to that instantaneous counting-rate, and if also we write a matrix synchronized with the scanning, then we build up a picture of the distribution of radioactivity.

The problem of observing the radiation through a small aperture presents difficulties, particularly with an extended source. If discrimination with respect to position is to be good, that is, if resolution of the picture is to be adequate, then we can only allow a very fine aperture; such an aperture, however, 'sees' only a small amount of radioactivity and the sensitivity of the system may therefore be very low.

The apparatus we have developed consists of three parts: (*a*) a mechanical scanning unit, (*b*) a pulse-shaping and integrating network, and (*c*) a display system.

The mechanical scanning unit (Fig. 1) comprises a head housing the detecting system, and capable of being moved so as to scan a preselected field uniformly and repetitively. This head consists of a block of lead of roughly elliptical cross-section, having in it three channels carrying respectively two Geiger counters and an optical system for producing a visible spot of light corresponding to the area 'seen' by one of the counters. The main protection of the counters is afforded by cylindrical blocks of tungsten alloy of high atomic number and having a density of approximately 16. These blocks have a length of approximately 6 cm., each block being about 3 cm. in diameter. Apertures of either 5 mm. or 3 mm. diameter have been drilled through this protective material, and the

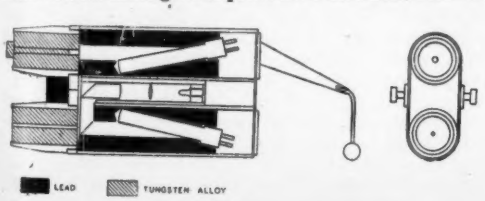

Fig. 1

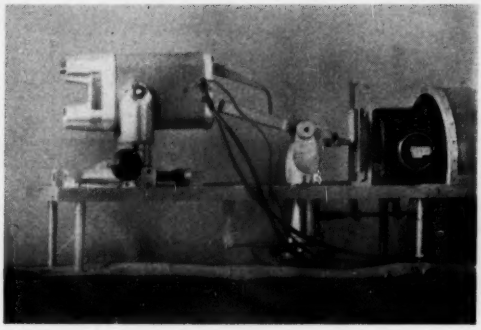

Fig. 2

radiation detected reaches the counter through one of these apertures. The head design is, in practice, a compromise between the demands of protection of the counter, on one hand, and, on the other, adequate sensitivity and mobility, the latter being of particular importance inasmuch as this heavy head has to be moved backwards and forwards accurately and consistently. The motion of the head is effected in our apparatus by rotating cams driven by a motor via a chain of gears. Two cams are so arranged that one produces a rotation about a vertical and the other about a horizontal axis. By careful design it was found possible to obtain relatively smooth motion with approximately uniform velocity. In this way (Fig. 2) the Geiger counter head, pivoted on an equatorial mounting, is made to move backwards and forwards, left to right and right to left, one complete cycle taking two seconds. We find experimentally that the beam retraces its path accurately and scans an approximately rectangular area the extent of which may be recorded by exposing photographic material in the path of the light beam.

A matrix of one hundred spots is obtained by two mechanical rotary switches driven from the motor. These switches select, in sequence, a series of potentials which are applied to the deflecting plates of the cathode-ray tubes in synchronism with the motion of the head. In this way we have applied ten potentials, thus deflecting the spot horizontally by ten consecutive steps. At the end of a line of ten spots the second switch comes into operation and deflects the spot one step vertically over a series of ten vertical steps. In this way we obtain a rectangular matrix of one hundred spots written downwards in a time of ten seconds. In early experiments we were impressed with the magnitude of the background even with a high degree of protection, and decided, therefore, to attempt to subtract this background automatically; hence the two counters in the head, one for main counting, the other to record the background and attempt to subtract it. In practice, we have found that in many circumstances background subtraction is not satisfactory, due to the asymmetry of the source with respect to the two counters; but if the source is at a fair distance from the head, the method appears to be fundamentally sound.

The pulses from the counter are first fed into a univibrator, the outgoing pulses of which, of constant size, then pass through a transitron pulse-shaping circuit. This network is necessary for the control of contrast in the final picture, since we obtain from the transitron circuit pulses of adjustable width, enabling us to obtain over a very wide range any required

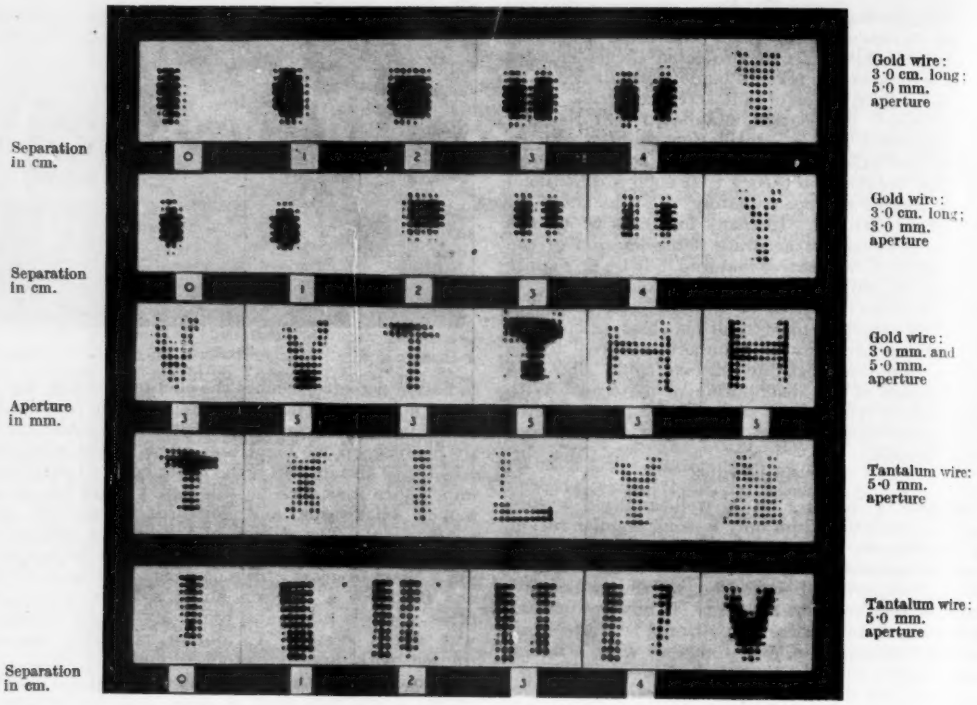
Separation in cm.
Separation in cm.
Aperture in mm.
Separation in cm.
Gold wire: 3·0 cm. long: 5·0 mm. aperture
Gold wire: 3·0 cm. long; 3·0 mm. aperture
Gold wire: 3·0 mm. and 5·0 mm. aperture
Tantalum wire: 5·0 mm. aperture
Tantalum wire: 5·0 mm. aperture

Fig. 3. Images of radioactive sources

D.C. voltage from a given number of pulses. The pulses from the transitron are then fed via a cathode-follower to the integrating circuit.

There are many possible methods of integrating these pulses and obtaining a proportional direct current. We have tried two of them, one using a simple time constant arranged to be slightly less than the duration of a single spot (that is, one tenth of a second), and a second method consisting of feeding groups of pulses corresponding to consecutive spots into consecutive condensers, and selecting resulting D.C. potentials in sequence with a mechanical switch. Experiments have been carried out with both systems, but at the present stage of development of the apparatus the former is simpler, though the latter should eventually give more accurate quantitative results. With either system we produce a D.C. voltage which is approximately proportional to the number of pulses which have occurred in the counting channel during the previous tenth of a second. By means of a balanced modulator driven by a local low-frequency oscillator, an output A.C. voltage of this same frequency is obtained the amplitude of which is fairly accurately proportional to the D.C. voltage. We may now feed this A.C. voltage into an amplifier of adjustable gain and take this amplified voltage through condensers to the control grids of the display oscilloscopes, one having a long-persistent screen for visual study and the second a blue screen for photography.

Some Theoretical Considerations

Some theoretical consideration has been given to the problems of the geometry of the systems of detection. Briefly, we may say that if we have a small point source and a detector of linear dimensions smaller than those of the aperture through which the radiation is coming, then we observe a fall in counting-rate in accordance with the inverse square law. If the source is still small and the detector fills the aperture, we still have inverse square law, but now to the aperture and not the detector. If, as is usually the case, the emitter is large enough to fill the aperture, then the conditions become more complex. If the source is, for example, a plane sheet of uniformly radioactive material and of infinite area, then as the source moves away the area 'seen' by the detector increases as the square of the distance, the radiation from each element decreases in the same ratio and the number of counts remains constant. If the source is linear the total amount of material 'seen' by the detector at any one time is approximately proportional to its distance from the aperture. We have verified experimentally that such relationships exist in practice. Simple calculations lead us to expect that in order to form a satisfactory visual image the detector of our system must 'see' at any moment approximately one half-millicurie of material, a result confirmed in practice.

We have not yet examined in detail the limit of photographic detection, but it is clearly very much lower. For example, a photographic exposure can easily extend over ten or a hundred sweeps; these hundred sweeps take place in about a quarter of an hour, which in many instances would be a reasonable time of exposure. It follows, therefore, that we may hope to photograph patterns corresponding to small fractions of a millicurie.

Experimental Results

Experiments have been carried out with active cobalt, tantalum, and gold wires arranged to form letters of the alphabet, in order to form an estimate of the capabilities of the instrument. Difficulties increase rapidly with increasing penetration of gamma radiation, but even with cobalt-60 we have found it possible to make reasonable visual images of simple sources. Fig. 3 shows the results of experiments with active gold and tantalum wires and illustrates the increased resolution obtained with a 3-mm. as opposed to a 5-mm. diameter aperture. The figure also indicates the degree of resolution obtainable as two parallel line sources are gradually moved relative to each other. It will be noted that the matrix of one hundred spots is adequate for these early experiments, resolution being determined largely by aperture diameter. The photographs represent reasonably the visual image produced on the long-persistent screen oscillograph.

In spite of obvious limitations we have produced with this apparatus recognizable visual and photographic images of radioactive sources, and are continuing with experiments to design and construct apparatus of greater sensitivity and resolution. We are also carrying out experiments with X-ray sources, as it seems that in the X-ray field the apparatus may have considerable application as an image amplifier. Other possibilities include studies of movement of radioactive materials by serial exposure, the formation of stereoscopic images and the direct presentation of the variation of counting-rate over an extended source. [Aug. 2.

[1] Maynecord, W. V., and Belcher, E. H., Supp. No. 2, *Brit. J. Rad.*, 259 (1950).

THE AMERICAN CHEMICAL SOCIETY AND INTERNATIONAL CHEMISTRY

THOSE who associate the United States with operations carried out with clockwork precision on a gigantic scale would not have been disappointed with the activities of the chemists who attended the Diamond Jubilee of the American Chemical Society in New York during September 3–7 and the Twelfth International Union and International Congress of Pure and Applied Chemistry during September 8–12; the Union completing its activities in Washington, D.C., on September 14–15.

The total enrolment for these events was more than 18,300. Detailed accounts of the proceedings of all three organizations, the technical sessions, lectures, speeches and dinners have already been published in the appropriate journals; indeed, three issues of the American periodical *Chemical and Engineering News* are almost entirely devoted to this subject. There were many interesting features well worthy of comment about these meetings of the largest collection of chemists ever assembled in the world.

While the annual meeting of the American Chemical Society was naturally a domestic affair, yet on this, its seventy-fifth meeting, that Society extended invitations to colleagues overseas and to other kindred domestic societies. There were present forty-one delegates representing societies from thirty-eight nations and seventy-seven delegates from domestic societies. The presentation of scrolls of congratulation took place in the Armoury in New York, where the delegates in their academic costumes were introduced in turn by Prof. Herman Mark to President N. H. Furman, who accepted the scrolls which were then placed by Secretary Alden Emery in a box on the stage. The ceremony on this gigantic scale was extremely impressive. It may not be generally known, but no less than 265 of the younger chemists from forty-five different countries were invited to the United States through the instrumentality of the Economic Cooperation Administration and the Ford Foundation. These had the opportunity of attending the meetings, visiting industrial plants in various sections of the country and of staying a few days in the homes of American scientific men to enable them to get a better appreciation of the American way of life. They were officially welcomed to the meeting by President Furman, Donald Shank of the Institute of International Education, Alden Boyd of the Economic Cooperation Administration and the Ford Foundation, and Alden Emery, the general secretary of the American Chemical Society. This was in addition to the hospitality lavished on the delegates themselves.

The importance of chemistry in the national life is a topic which usually receives attention only from the chemists themselves, but it may be of some importance to other countries to note that at these meetings there was read a letter of welcome from President Truman; an official civic welcome by the City of New York on the steps of the General Post Office; an unveiling of a bronze plaque by Dr. C. Parsons, former secretary of the American Chemical Society, on the wall of the house where the Society was founded seventy-five years ago in Washington Square, the Chelsea of New York; an able address by Governor Driscoll of New Jersey on "Politics in an Age of Science"; a speech by Allan Berkley, the Vice President of the United States, on the "Chemical Problems of the Farmer", in which he reminded his audience of the fact that Thomas Jefferson had regarded chemistry as "the most useful of sciences, big with future discoveries for the utility and safety of the human race". Finally, in Washington an after-dinner speech was given to the delegates of the International Union by Charles Sawyer, U.S. Secretary of Commerce.

The U.S. post office issued ten million commemorative stamps, of which, I believe, more than 2½ million were sold within the first two days.

The formal meetings and dinners were diffused over the country both by radio and television; a number of the official delegates found several days exposure to 'Kleg' lights rather tiring. It was also significant that the three public speeches addressed to the American Chemical Society all dealt with the future rather than with past achievements; that of President Furman reviewing the present and indicating the future developments within the Society. Dr. J. B. Conant, president of Harvard, chose as his text "A Skeptical Chemist looks into the Crystal Ball", and Dr. Kenneth Mees, of the Kodak Co., dealt with "The View Ahead in Chemistry". These prophets were as optimistic as those who stood before Lars Porsenna.

Both English and American chemical journals and abstracts play a large and important part in world chemistry, and it is evidently desirable that such technical matters as symbols, nomenclature and

abbreviations should be as uniform as is possible. This meeting of the American Chemical Society provided a welcome opportunity for those responsible on both sides of the Atlantic to meet and discuss this important matter. Semantics give us no decision between 'sulphur' and 'sulfur' or 'aluminium' and 'aluminum', but the two countries have found it possible to adopt the same symbols and identical logical methods for the necessary chemical shorthand.

As the oldest national chemical society, the president of that of Great Britain was asked to convey the congratulations of the chemical societies invited to this meeting to our hosts; and Arthur B. Lamb, professor emeritus of Harvard, past editor of the *Journal of the American Chemical Society*, was made an honorary life member of the Chemical Society in Great Britain.

In the proceedings of the International Congress, the world-wide ramifications of chemistry were most clearly revealed by the fact that the four official public lectures were given respectively by Prof. V. Deulofeu of Buenos Aires, Prof. K. U. Linderström-Lang of Copenhagen, Dr. E. W. R. Steacie of Ottawa, Canada, and Prof. A. R. Todd of Cambridge in England, while the various committees and commissions of the Union and sections of the Congress were naturally international in character.

In Washington, the Union members were looked after by Dr. E. U. Condon, of the Bureau of Standards, and Dr. D. W. Bronk, of the National Academy of Science. The most important international action completed by the Union consisted in the re-admission of Japan and the admission of Western Germany and New Zealand to the Union. This meeting of the Union terminated the period under the presidency of Prof. H. R. Kruyt. Chemists who have the world interests of chemistry at heart are deeply indebted to one whose wisdom and skill have steered the Union through the difficult post-war period to a position in which it finds itself a living entity and has a real purpose in the complex times in which we live. Prof. Arne Tiselius was unanimously elected as successor, and the next meeting of the Union will be held in Stockholm in 1953. While the sectional meetings, of which there were so many, were managed with the skill born of long practice by the American Chemical Society, it proved too much for the Union, which found that having a congress of pure and applied chemistry on its hands was no joke. Delegates to the Union who thought they had sufficient work to do in the Union itself found that they had, in addition, to participate in many Congress activities. This, indeed, may be the last of the Congresses devoted to all phases of chemical activity. In Stockholm the Congress activities will be restricted to physical chemistry and one or two special topics.

All visitors to the United States are always impressed by the kindness and hospitality of their hosts. Those who attended these conventions will never forget the attentions showered upon them by American individuals, civic authorities, societies and industrial organizations for fourteen memorable days.

Eric K. Rideal

TWELTH INTERNATIONAL CONGRESS OF PURE AND APPLIED CHEMISTRY

THE Twelfth International Congress of Pure and Applied Chemistry was held in New York during September 9–13, immediately following the Diamond Jubilee celebrations of the American Chemical Society. Chemists attending the Congress came from forty-two countries and, of more than nine hundred papers presented, about one-third were by chemists from countries outside the United States. Through the help of the Economic Co-operation Administration and also the Ford Foundation, a number of young chemists from foreign countries were able to attend the Congress and, after its conclusion, were taken on tours of the principal industrial centres of the United States. The Congress was divided into sixteen general sections, but, due to the large number of papers presented, some of these had to be subdivided further. In addition, a general lecture was given each day by a leading chemist (two from Europe, one from North and one from South America) to a combined meeting of all sections.

The first of the general lectures was given by Dr. E. W. R. Steacie, Division of Chemistry, National Research Council of Canada, and was entitled "The Decomposition of Organic Compounds". Taking as examples the thermal decomposition of ethane and the reaction of a methyl radical with an aliphatic hydrocarbon, he reviewed the different approaches and trends over the past few years in the field of gas-phase reaction kinetics. He stressed that, though the original postulates and calculations about free-radical mechanisms have been useful in directing the investigations to date, much more experimental data are needed on a variety of simple reactions. The theoretical approach now involves too many assumptions and approximations, and can only be further advanced when reliable experimental data have been amassed.

Prof. K. U. Linderström-Lang, of the Carlsberg Laboratories, Copenhagen, discussed, in his lecture "Structure and Enzymatic Breakdown of Proteins", the chemistry involved in the conversion of ovalbumin to plakalbumin. He presented evidence showing that when the protein ovalbumin is attacked by a bacterial proteolytic enzyme, the formation of plakalbumin II may correspond to the loss of a hexapeptide unit from the ovalbumin molecule. A reaction also occurs in which plakalbumin I is first formed, corresponding to the removal of a dipeptide (alanyl-alanine) from the original molecule, and then a tetrapeptide is split off more slowly to yield plakalbumin II. It was pointed out that although this comparatively small change in composition, namely, the removal of a peptide of low molecular weight, produces a remarkable change in the crystal form and solubility of the protein, dilatometric studies now reveal that there are other more profound changes in the molecule.

In the third lecture of the series, Prof. A. R. Todd, University of Cambridge, discussed "The Chemistry of the Nucleotides". Reviewing recent work in this field, particularly that [illegible] Cambridge group, Prof. Todd considered [illegible] aches to nucleotide chemistry in relation to [illegible] cid structure. Three chemical problems are [illegible]: the structure and synthesis of nucleo[illegible] phosphorylation of these to give nucleotid[illegible] the method of linkage of dissimilar bodies t[illegible] the phosphoric acid group. In discussing [illegible], the proof of the β-glycosidic linkage in the nucleosides was described, followed by an account of the use of dibenzyl-chlorophosphonate as a mild phosphorylating agent. The uncertainty of the location of the phosphate group on either the 2- or 3-position of ribose in the nucleotides was explained by the possible cyclization

of the phosphate group across these positions. This would also account for the alkali-instability of ribonucleic acid and for the isolation of isomeric adenylic acids by Carter and Cohn. In the light of the known chemical properties of the nucleotides, particularly their behaviour to acid and alkali, possible structures of ribo- and deoxyribo-nucleic acids were considered.

In the final lecture of the Congress, Prof. V. Deulofeu, National University of Buenos Aires, gave a short talk on "The Chemistry of some South American Plant Products". This dealt with the chemistry of the alkaloids and flavonols found in various plants and bushes in that region. The structure of γ-fagaradine and the other alkaloids from the plant *Fagara coco* was discussed by considering their relation to dictamine. The theoretical basis for their various reactions was considered, and the synthesis of analogues of α-fagarine with comparable pharmacological activity was described. The three Argentine species of *Erythrina* examined contain two main alkaloid fractions, one group being the free bases (for example, erythramine, erythratine), while the others are glycosidically bound and only liberated in extractable form by acid hydrolysis (for example, erysotrine, erysovine). The structure and inter-relation of these compounds and their relation to the parent base erythradine were discussed.

Several of the larger sections of the Congress organized their programmes to include symposia on particular aspects of current interest. Thus the Medicinal Chemistry Section, for example, held symposia on antibiotics, tuberculosis and cancer. In these the stress fell mainly on the chemotherapeutic approach, several papers being presented on the new antibiotic 'viomycin', derived from *Actinomyces vinaceus*, and on the use of compounds of the thiosemicarbazone group against tuberculosis and of the derivatives of ethyleneimine against cancer. The Biological Chemistry Section held a two-day symposium on proteins and amino-acids, and also symposia on nucleic acids, enzymes and microbiological chemistry. The sections entitled Plant Cell-wall Constituents, Air and Stream Pollution, Pesticides, etc., held symposia on specific aspects in those fields. The Physical and Inorganic Chemistry Section and the Organic Chemistry Section arranged very large general programmes covering many aspects.

The field of chemistry has now become so vast that for future international meetings it seems it will be necessary to subdivide the Congress into independent units. Accordingly, the next International Congress of Chemistry, to be held at Stockholm in 1953, in conjunction with a meeting of the International Union of Pure and Applied Chemistry, will be restricted solely to the Physical Chemistry Section.

D. HAMER

OBITUARIES

Mr. James Baddiley

MR. JAMES BADDILEY, who died in hospital on September 26, was one of the outstanding leaders in the renaissance of the dyestuffs industry in Great Britain. He was born in Yorkshire on July 15, 1885, and educated at Bradford Grammar School, whence he went to the University of Leeds and graduated with first-class honours in 1907. He then worked for two years with Prof. A. G. Green in the Clothworkers' Research Laboratory, and during this period published, with Green, in the *Transactions of the Chemical Society*, a paper in a series on colouring matters of the stilbene group, dealing with the action of caustic alkali on derivatives of *p*-nitrotoluene. In 1909 he joined Levinstein's, Ltd., at Blackley as research chemist, and in the next five years he worked chiefly on azo dyestuffs and intermediates, work which issued in twelve British patents with Dr. H. Levinstein as co-inventor.

By the outbreak of war in 1914, Mr. Baddiley had already established his reputation as a research chemist, and he quickly became the head of the Technical Research Department at Blackley, of which he retained charge when the British Dyestuffs Corporation was formed. In 1925, Prof. A. G. Green having meanwhile resigned his post as director of research, Baddiley became manager of the Research Department. In 1930, the British Dyestuffs Corporation having become part of Imperial Chemical Industries, Ltd., Mr. Baddiley became a delegate director, and joint technical manager of the Dyestuffs Group, remaining director in charge of research until his retirement in 1947.

Although only one scientific paper stands in his name, he was cited as co-inventor on some sixty British patent specifications. When the Board of Trade Dyestuffs Development Committee issued its first report in August 1920, it referred to five outstanding developments in dyestuffs chemistry, three of which were British discoveries, and with two of these Mr. Baddiley was associated. One was his discovery in 1922, with the late Mr. A. Shepherdson, of the valuable dyeing properties of dispersions of unsulphonated amino derivatives of anthraquinone for acetate rayon; the other was his contribution to the use of dispersions of azo dyestuffs for the same purpose. Both discoveries considerably assisted the development of the use of cellulose acetate as a textile fibre. A further discovery, also listed by the Dyestuffs Development Committee in its report, with which Mr. Baddiley was associated, was that of a special range of azo dyes giving level shades on the 'irregular' viscose rayon which at that time was frequently encountered. Mr. Baddiley's services to the industry were recognized in February 1939 by the award to him of the Perkin Medal of the Society of Dyers and Colourists. This, the premier award in the field of dyes and their application and textile chemical technology, was awarded "in recognition of his national services for the renaissance of the British dyestuffs industry through many important investigations in the field of colouring matters conducted or directed by him".

Mr. Baddiley retained to the end his interest in and enthusiasm for dyestuffs technology and organic chemistry, remaining a keen student of the literature. Only his last illness prevented him from presenting a paper he had prepared for the Society of Dyers and Colourists' conference last September. Outside chemistry his chief interests were in his family and, in early life, walking in the Peak district, the Lake district, or his native county, of the fells and inns of which he had an extensive knowledge. He came of farming stock and had also a keen interest in agriculture.

On the research side at least, no one else can have played a part in the renaissance of the British dyestuffs industry in any way comparable with that of Mr. Baddiley; but some who knew him may remem-

ber him as much as an inspirer and encourager of others as for his own technical achievements. A wide circle of colleagues who regret the passing of one who earned their respect and affection will extend their sympathy to his widow and children.

Dr. A. L. Green

We regret to report that Dr. Alfred Leonard Green, who was officer in charge of the Ionospheric Prediction Service of the Commonwealth Observatory, Mount Stromlo, Canberra, died in Sydney on August 29, after a trying illness. Dr. Green was born in 1905 in London and educated at Bancrofts School, Essex, from which he proceeded to King's College, University of London. In 1927 he became assistant to Sir Edward Appleton, and was engaged on investigations on the ionosphere, and in 1930 he joined the staff of the Radio Research Board in Sydney. He at once made an investigation of the polarization of down-coming waves in the southern hemisphere and found that it was opposite to that in the northern, thus carrying out a crucial test of the magneto-ionic theory. Dr. Green continued with the Radio Research Board, for which he conducted a number of important investigations, until 1935, when he joined Amalgamated Wireless (Australasia), Ltd., becoming chief of the Research Laboratories. In 1947 he became officer in charge of the Ionospheric Prediction Service at the Commonwealth Observatory, and introduced considerable improvement into the methods of forecasting. He was about to organize a programme of experimental work in the various ionospheric stations operated by the Service, the staff of which he had recruited, when he was incapacitated by his last illness. Green was a Ph.D. and later D.Sc. of the University of London. He is survived by a widow.

R. v. D. R. Woolley

NEWS and VIEWS

Nobel Prize for Medicine for 1951: Dr. Max Theiler

Dr. Max Theiler, who has been awarded the Nobel Prize for Medicine for 1951, was born in South Africa in 1899, a son of Sir Arnold Theiler, whose work in veterinary problems in Africa is widely recognized. Dr. Max Theiler received his medical education at St. Thomas's Hospital, London, and graduated in 1919. Upon completion of a course at the London School of Tropical Medicine, he accepted a post at Harvard University in the Department of Tropical Medicine, where his work ultimately led to the demonstration of the susceptibility of white mice to intra-cerebral inoculation of yellow fever virus. This made possible for the first time work with yellow fever virus in a small and inexpensive animal. Dr. Theiler eventually developed the mouse protection test which has become one of the principal tools in yellow fever epidemiology. It was after Dr. Theiler had moved to the International Health Division of the Rockefeller Foundation in New York that the historic discovery of the inocuous nature of the 17 *D* sub-culture of the well-known Asibi strain of yellow fever virus was made. This is the strain which served for the major portion of the millions of yellow fever immunizations given during the past decade. If further evidence of Max Theiler's careful workmanship is necessary, this is furnished by his discovery of the interesting murine encephalomyelitis virus which bears his name.

Dr. Theiler is certainly one of the most modest of men. He rarely attends scientific meetings, despite an extremely affable and friendly nature, and in his laboratory he seldom presents a picture of the intensity which is customarily expected of the scientific investigator. This easy-going approach to his work, however, disguises very effectively the enormous amount of thinking which lies behind each and every one of his experiments. He is most characteristically found sitting at ease in his laboratory, examining and re-examining the results of the experiments being conducted by his team of very competent technicians, whom he has himself trained. While he will no doubt be greatly pleased by the award of the Nobel Prize, it is unlikely that the very human Max Theiler will be changed one whit by it.

Grande Médaille Osmond: Prof. E. N. da C. Andrade, F.R.S.

On October 26, during the autumn conference of the Société Française de Métallurgie, Prof. E. N. da C. Andrade was presented with the Grande Médaille Osmond, a premier award in the field of metallurgical science. This honour was instituted in 1949 on the occasion of the centenary celebrations of the birth of Floris Osmond, a pioneer in metallography, and is awarded—to translate literally the conditions laid down—"without condition of nationality, in principle every two years, to a metallographer whose scientific works have had important consequences for metallurgy and the study of metals, so as to constitute a crowning award to work judged of first importance in metallurgical science". The first award was made to the distinguished Swedish man of science, Prof. Carl Benedicks. Present-day knowledge of deformation processes in metals owes much to the painstaking work and penetrating observations of Prof. Andrade. His early experiments on the creep of metals led to the relationship now generally known as the 'Andrade creep law', and to the recognition of the fact that at least two physically distinguishable processes play a part in creep phenomena. He was among the earliest investigators to prepare single crystals of metals and study their deformation. Characteristically, he devised methods for the preparation of the more difficult materials and elucidated their modes of deformation. The methods he devised, both for preparation and testing of the materials, have found widespread use in laboratories all over the world. More recently, his work has established the importance of the role of the surface in the mechanical behaviour of both polycrystalline and monocrystalline metals. Already, as with many other phenomena to which he first directed attention, these observations have been pursued by other workers with fruitful results. This work, for which the Médaille Osmond has been awarded, constitutes, of course, but a part of Prof. Andrade's contributions to science as a whole; his original work has ranged over the whole field of physics, while he has yet found time to interpret science to the layman and make significant contributions to the literature of the history of science.

Mechanical Engineering Research Organization : Dr. D. G. Sopwith

Dr. D. G. Sopwith, until recently superintendent of the Engineering Division, National Physical Laboratory, Teddington, has been appointed director of mechanical engineering research in the Department of Scientific and Industrial Research in succession to the late Dr. G. A. Hankins. Since the death of Dr. Hankins in November last year, Dr. Sopwith has been acting director. He will now take complete charge of the new Mechanical Engineering Research Organization, the laboratories of which at East Kilbride, near Glasgow, are already partially built (see p. 779). Dr. Sopwith, who is forty-five years of age, was born in London and was educated at Manchester Grammar School and the University of Manchester. At the University he obtained a Whitworth Scholarship and graduated with first-class honours in mechanical engineering in 1928. He then joined the staff of the National Physical Laboratory, Engineering Division, becoming superintendent of the Division in 1948. He has published many papers on a wide range of subjects, including the design and causes of failures of engineering components, and others on chains and lifting gear, fatigue, helical compression springs, screw threads, the penetration of armour plate, and breech mechanisms.

British Caribbean Meteorological Service : Mr. W. A. Grinsted

Mr. W. A. Grinsted, director of the newly established British Caribbean Meteorological Service, has recently taken up his appointment at the headquarters of the Service in Trinidad. Mr. Grinsted joined the Meteorological Office in 1920 and was appointed to the British East African Meteorological Service in 1934. In 1942 he was made assistant director of what, in 1948, was to become the Meteorological Department of the East Africa High Commission. Since the Second World War, meteorological services in the Caribbean have been operated by the Air Ministry. The establishment of the new Service was recommended by a conference which met in Trinidad in January, at which it was decided that the Government of Trinidad and Tobago would administer the scheme on behalf of the other Governments concerned, though the director would have direct contact with the other Governments. The cost of the new Service will be met by these Governments, assisted by grants from Great Britain from Colonial Development and Welfare Act funds and by a contribution from the Ministry of Civil Aviation.

Leadership Training in the Universities

Sir Walter Moberly's Walker Trust Lecture on Leadership, which he delivered to the University of St. Andrews on February 13, and which is now published (London : Oxf. Univ. Press. 2*s*. 6*d*.), was an examination of the grounds on which the universities' traditional task of leadership is disclaimed to-day. Sir Walter suggested that there is no longer a keen demand for the qualities fostered by a traditional university education, and that for the universities to aim deliberately at producing numbers of a ruling class is wrong in principle as well as impracticable. Again, even if education for leadership were a desirable aim in itself, we are now asked whether, in the present cultural situation, it is possible for the universities to impart it or for students to acquire it. It is urged by Mr. T. S. Eliot that we are sacrificing quality to quantity and that the training of an élite of gifted individuals cannot entirely compensate for the disappearance of an upper class. Finally, the disappearance of any ground-pattern of common belief and behaviour is a crippling handicap. Sir Walter concedes the weight of these objections, but maintains that education for social responsibility is nevertheless still a legitimate and essential task of the universities. Whenever the management of affairs or the guidance of public opinion is left to persons or groups who are not really respected, the life of the community suffers. "The imaginative understanding which illuminates facts" is the one quality most urgently needed in statesmen and all leaders of opinion to-day. If the universities are still to educate for leadership, but for leadership of a more novel kind, Sir Walter suggests first that the family life of the university to-day needs special emphasis. Next, members of a university community should go out of their way to mix with those whose background, professional interest, opinions, and perhaps nationality, differ from their own ; and thirdly, they should seek to avoid the danger of narrowness, for example, by everyone examining the tacit assumptions of his own subject of study and by thinking strenuously about the great issues of right and wrong, liberty and order, faith and scepticism.

Royal Meteorological Society : First Annual Dinner

The Royal Meteorological Society celebrated last year its centenary, and this year the new session commenced with the inauguration of the Society's first annual dinner, which was held on October 17 in London. The Society's new president, Sir Charles Normand, welcomed the guest of honour, Sir John Slessor, chief of Air Staff, who in proposing the toast of the Society gave many important instances of the use of meteorology as a weapon of war, particularly in aviation. Sir John pointed out, however, that aviation is equally important to meteorology. The Meteorological Research Flight at Farnborough, for which the R.A.F. supplies the aircrews and the Meteorological Office the scientific observers, has rendered unique service to meteorological research. In responding, the retiring president of the Society, Sir Robert Watson-Watt, drew a careful distinction between the Royal Meteorological Society and the Meteorological Office. Sir Robert commented on the disparity in the *per capita* expenditure in Great Britain on meteorology and that in the United States, which is greater in the ratio of 17 : 10. An expansion of the meteorological service would be of great value to Britain, not only to aviation but also in many other directions, and notably to agriculture.

The Wood Pigeon in Britain

For many years it has been recognized that the wood pigeon in Britain is harmful to agriculture, and varied attempts have been made to prevent its depredations. With the coming of the Second World War, renewed interest was taken in the protection of growing crops and in reducing the number of wood pigeons. In due course the British Trust for Ornithology received a grant from the Agricultural Research Council for research on the biology and control of this species. During the war years the Wood Pigeon Investigation, which was given facilities for working

at the Edward Grey Institute of Field Ornithology, Oxford, was naturally preoccupied with the problem of control, and research on the habits of the species was built up on this central theme. For example, a survey of nests was undertaken with the object of discovering whether the pigeons could be controlled in their breeding quarters; plumage was studied to obtain a clue to the migration problem; a knowledge of the relative density of the population was obviously desirable; and a similar knowledge of the feeding habits and feeding grounds was essential for the main purpose in view. The work on control has now been closed and it is possible to knit together the results of research on the biological side, which together form a study of the effect of human activities on one species of bird. Although the wood pigeon is as wild and unapproachable as any member of the British fauna, it would be difficult to name any animal the life-history of which is more closely interwoven with that of man. This life-history has been described by M. K. Colquhoun in an account which should be of interest not only to ecologists but also to those associated with the practice of agriculture and forestry (Agricultural Research Council. Report Series No. 10. London: H.M.S.O. 3*s*. net).

Material Culture of a Micronesian Atoll

Kapingamarangi, an atoll south of the Caroline Islands and just north of the equator, was chosen as the field for an expedition to Micronesia, since it was known to be inhabited by a Polynesian stock. The people are taller and more robust than the Micronesians, with typically Polynesian brown skin and wavy or curly hair, and they are friendly and hospitable. There are thirty-three islets on the reef around the central lagoon, with a population of more than five hundred. This atoll, then, formed a highly compact area for an intensive survey—and how intensive it was is shown by an account of "Material Culture of Kapingamarangi", by Te Rangi Hiroa (Peter H. Buck) (Bernice P. Bishop Museum, Honolulu; Bull. 200; pp. 291; 1951). The field has been covered minutely, and the profuse illustrations are of high merit; in fact, the whole publication serves as a model of how such a survey should be presented. It is interesting to find a community nowadays living such a balanced life. They are isolated, but not entirely so; they are self-supporting, healthy and happy, and what outside culture—social and material—they now desire can be supplied by their outside contacts. Let us hope that this balance is not upset by so-called civilization.

Library Catalogue of the Timber Development Association

The Timber Development Association, Ltd., has at its headquarters (21 College Hill, London, E.C.1) a library containing more than a thousand books treating of matters of importance in the timber and wood-working industries, and so forth. The titles of these books are given in the "Library Catalogue" (pp. 54), the third edition of which appeared in April 1950 and was reprinted in February 1951. The catalogue does not include any of the many brochures, pamphlets, and trade catalogues which may be inspected at the headquarters. The catalogue is drawn up on the usual lines, and forms a valuable aid to those who are associated with timber development.

World Power Conference: Annual Report for 1950

The annual report of the World Power Conference for 1950 (pp. 22; London: World Power Conference, 1951) records the admission of Iceland and Israel to membership at the 1950 meeting of the International Executive Council, and national committees have been formed in both countries. A brief chronicle of the Fourth World Power Conference is appended to the report, and the transactions of the Conference are being prepared for publication. The International Executive Committee protested unsuccessfully against the decision of the Economic and Social Council of the United Nations to transfer the World Power Conference from the list of organizations having category-*B* consultative status to the Secretary-General's Register. A list of publications as well as the statement of accounts is appended to the report, the income and expenditure account showing a deficit of £261 on the year.

"Runs in a Sequence of Observations"

Referring to the communication under this title published in *Nature* of September 29, p. 557, Prof. P. V. Krishna Iyer writes: "The determinantal difference equation should be read as follows: The difference equation reduces to a determinant of the k^2 order given by

$$\| A_{rs} \| \varphi(m-2) = 0,$$

where A_{rs} is a $k \times k$ matrix such that when $r \neq s$, all rows excepting the sth row are zero, the sth row being $[-p_r t \ -p_r t \ \ldots \ -p_r t]$. When $r = s$, the rth row is $[-p_r t \ -p_r t \ \ldots \ (E-p_r) \ \ldots \ -p_r t]$, the diagonal elements are $[E \ E \ E \ \ldots \ E-p_r) \ \ldots \ E]$, all the other terms being zero".

University of London

The following announcements have been made by the University of London. Mr. A. G. Smith has been appointed to the University readership in applied thermodynamics tenable at the Imperial College of Science and Technology. Doctorates have been conferred as follows: *D.Sc.*, J. G. Boswell (King's College), Miss M. S. Lesslie (Bedford College), Miss L. M. Pickford (University College) and F. L. Warren (Imperial College of Science and Technology); *D.Sc.(Eng.)*, F. W. Preston (external student).

Announcements

Mr. Ben Smith, national organizer of the Association of Scientific Workers, has been appointed general secretary of the Association in succession to Mr. T. Ainley.

The new laboratories of the British Food Manufacturing Industries Research Association at Randalls Road, Leatherhead, will be opened by Lady Engledow on November 8.

A British Commonwealth Scientific Official Conference will be held in Australia in 1952. This is the first time the Conference has been held outside the United Kingdom; the last Conference met in London in 1946. The Conference will open in Canberra on February 18, and will close in Melbourne on March 7; the formal sessions will be broken by visits to enable delegates to study problems of Australian development. Local arrangements for the Conference are in the hands of the Commonwealth Scientific and Industrial Research Organization, 314 Albert Street, East Melbourne.

REPRODUCTIVE ORGANS OF NEAR-TERM AND NEW-BORN SEALS

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THERE is convincing physiological evidence indicating that, in several species of mammals, including man, horse and donkey, œstrogens and progesterone are elaborated by extra-ovarian tissues[1,2]. It is generally believed that the placenta represents the new source, though the available evidence falls short of finality[3,4].

The genital organs of the human infant at birth and of the fœtal foal show characteristic gross and microscopic alterations, and it is evident that they have been exposed to strong and physiologically effective stimulation from endocrine substances. Histological and biochemical investigations, fully presented for man by Fraenkel and Papanicolaou[5], and by Dobszay[6], and for the horse by Cole, Hart, Lyons and Catchpole[7], and by Amoroso and Rowlands[8], have revealed certain details of these transitory phenomena. On the other hand, data regarding the histological structure of the reproductive tract in mature fœtuses or in the new-born of other species have not been reported in sufficient detail to enable comparisons to be made, or to assess the endocrine status of the extra-ovarian tissues that may be involved. In the cat, for example, the uterine glands of the new-born kitten are stated to be active; but this activity ceases soon after birth[9], while in mature fœtuses of the African elephant, Perry[10] has described a pronounced enlargement of the gonads which regresses soon after delivery.

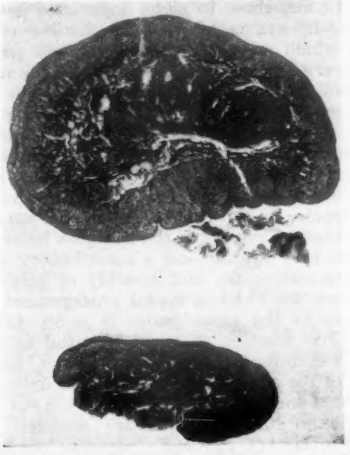
We have recently examined the reproductive organs of a number of near-term and full-term seal fœtuses, and new-born and recently born seal pups of both sexes. In several instances the maternal ovaries and portions of the maternal genital tracts have been sectioned. Material from different species (*Halichœrus grypus*, *Phoca vitulina* and *Callorhinus ursinus*, and three species of Antarctic seals, *Leptonychotes weddelli*, *Lobodon carcinophaga* and *Hydrurga leptonyx*) has been examined. The gross and microscopic findings are essentially similar, although not yet confirmed at every stage, for each species. We find a remarkable enlargement of the gonads of all near-term fœtuses and new-born pups, an observation already made by one of us[11] in *P. vitulina*. A characteristic hypertrophy and engorgement of the uterus, changes in the vaginal epithelium and a large plug of tenacious mucus in the anterior vagina are associated with this phenomenon.

The ovaries of near-term and new-born seals present a picture which is remarkably different from the appearances seen some weeks after birth[11]. The ovaries are strikingly enlarged—larger, in fact, than those of the mother—but are devoid of follicles in a stage of development more advanced than those lined by a single layer of follicular epithelium. The large size is due to an especially developed proliferation of interstitial cells which make up the bulk of the organ. At birth the ovaries weigh 32–36 gm. and those of the mother weigh 25–28 gm.

In the ovary of the new-born, the primordial follicles lie immediately below the tunica albuginea and tend to be arranged in clusters in the neighbourhood of sub-surface crypts of germinal epithelium, which are present at irregular intervals in the cortical zone[12,13]. The remainder of the organ consists mainly of loosely arranged, well-vascularized interstitial tissue. The interstitial cells are large, oval or polyhedral, and have abundant eosinophilic cytoplasm. In the majority of cells, the nucleus is eccentrically placed and is large and vesicular; but it is occasionally shrunken and pyknotic.

Involution of the ovaries begins three or four days after delivery and is well advanced by the second week (see illustration). The ovaries weigh 8–10 gm. during the second week, and 2–4 gm. when involution is completed. During involution the interstitial cells undergo a lipid transformation, shrink considerably and become densely packed. The majority of the nuclei are now shrunken and pyknotic.

The uterus of new-born seals is relatively large and congested, and, as in the human neonate[6], the cervical canal is more definitely patent during the neo-natal period than immediately thereafter. Macroscopically the uterine horns resemble those of the bitch when in œstrus. In sections, the uterine mucosa is thickened and the uterine epithelium is frequently several layers thick. The uterine glands are numerous,



Photograph of longitudinal sections through the greatest diameter of (above) full-term fœtal and (below) approximately week-old phocid ovaries. Natural size

enlarged and extend in coils to the base of the mucosa. There is definite evidence of active secretion. A week after birth the uterus has started to shrink; the uterine epithelium is single-layered, the glands are smaller and their cells heavily vacuolated, and there are only traces of secretion.

The vagina contains a large coherent plug of thick mucus lying immediately caudal to the cervix uteri. During involution, the amount of mucus in the vagina decreases and the viscosity is lowered. Histologically, a multi-layered hypertrophy of the epithelium of the posterior vagina prevails; but anteriorly it is converted into a mucus-secreting type, frequently with a superficial layer of tall columnar cells, and containing occasional, large, darkly staining, granular cells, the nature of which has not yet been determined. The secretions which accumulate in the lumen of the vagina contain desquamated epithelial cells in addition to red and white corpuscles. Usually the extravasated blood in the vagina is small and insufficient to colour the mucus, but occasionally—and especially during involution—it may accumulate in such quantities to stain the secretions a dark red colour. About a week after birth the vaginal epithelium is thinner, and in many places has the appearance of a transitional epithelium.

In male pups the gonads follow a similar curve of growth and decline as do the ovaries, and in the new-born weigh 34–40 gm. The testes are covered by a well-defined tunica albuginea which varies in thickness from 600 to 800 μ. They contain large islands of interstitial tissue, between which are found numerous, convoluted seminiferous tubules that contain an occasional spermatocyte. The majority of the tubules are patent, but some are solid. On an average, the tubules measure about 60 μ in diameter.

Our observations on the maternal ovaries just before, during and after parturition confirm those of Enders, Pearson and Pearson[14]. The ovary containing the heavily vacuolated corpus luteum of pregnancy possesses very few, small atretic follicles; the other contains numerous healthy follicles 0·2–4 mm. in diameter and frequently, as in one cow which died during labour, one or more follicles up to 12 mm. in diameter. It is one of these larger follicles which is probably destined to rupture at the post-parturient ovulation some three to eight days after delivery.

The modifications of the reproductive organs of the seal which normally prevail at birth parallel in almost every respect those described in the new-born infant and the fœtal foal. But whereas the changes in the uterus and vagina of the aforementioned species can be ascribed almost entirely to circulating œstrogens, the occurrence of coiled endometrial glands and vaginal mucification in the seal suggests that progesterone is acting upon an œstrogen-primed genital tract. It is probable from the appearances of the maternal ovaries in the seal just before and at birth that they are at least a contributory source of circulating œstrogens, and possibly of progesterone. The extent to which gonadal enlargement can be attributed to the same cause is more difficult to assess. The reaction of the interstitial cells in the gonads resembles a response to the luteinizing fraction of the anterior pituitary; and unless we can assume that endocrine substances having the property of chorionic gonadotrophin are secreted by the cytotrophoblast of the seal's placenta (as has been demonstrated for man), then the remarkable changes in the ovary of the seal at birth might be ascribed to the presence of circulating œstrogens or to changes in the kind and quantity of gonadotrophic hormones secreted by the fœtal pituitary. [June 26.

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CHEMISTRY OF THE OXIDATIVE METABOLISM OF CERTAIN AROMATIC COMPOUNDS BY MICRO-ORGANISMS

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AND

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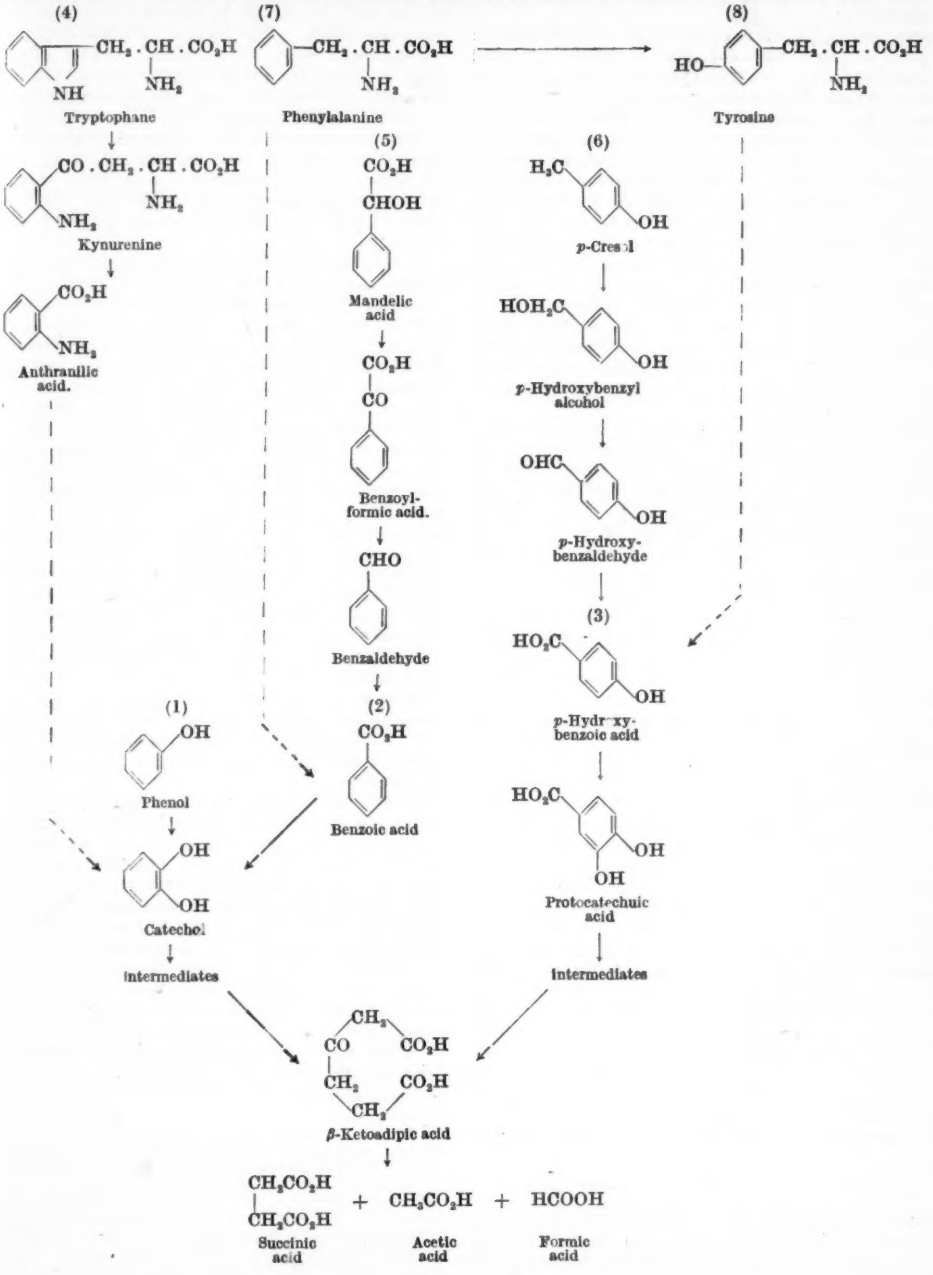
SEVERAL types of micro-organisms, classified into the following six families, Coccaceæ, Mycobacteriaceæ, Bacteriaceæ, Pseudomonadaceæ, Spirillaceæ and Bacillaceæ, are known[1], which grow in a simple mineral salt medium with an aromatic compound as the sole source of organic carbon. During growth, the benzene ring undergoes fission, the compounds formed being utilized in the diverse processes associated with cell metabolism. Such organisms have been isolated from soil, sewage and mammalian fæces, and are widely distributed in Nature. Indeed, the biological function of these micro-organisms by virtue of this property may be regarded as an essential step in the 'carbon' cycle. Their use as industrial scavengers is common, since percolation of phenolic waste-products through sewage beds provides a cheap method of detoxicating aromatic substances potentially harmful to aquatic life. Useful reviews by ZoBell[2] on the bacteriological aspects of this phenomenon have been published.

The biochemistry of bacterial aromatic ring fission has been investigated by the application of two entirely distinct methods of approach, and has been reviewed by Happold[3]. These are the traditional one of attempting the isolation of intermediates from growing cultures, mainly by Evans and Happold and their collaborators, and, secondly, through the utilization of the technique of 'simultaneous' or 'successive' adaptation by Stanier. Recently, cell-free enzyme preparations from bacteria which have grown on one aromatic substrate, and therefore

TABLE 1. PATHWAYS IN THE OXIDATIVE BACTERIAL METABOLISM OF SOME BIOCHEMICALLY IMPORTANT AROMATIC COMPOUNDS



possessing the adaptive enzyme pattern for its metabolism, have yielded important new information concerning the chemical steps in this metabolic pathway.

Table 1 summarizes the knowledge gained by several investigators concerning the bacterial 'aromatic fission' type of metabolism of some biochemically important substances.

It is now generally recognized as desirable that before any presumed intermediate is finally accepted as participating, it must, first, obey the criteria of simultaneous adaptation and, secondly, have been identified chemically, either from the culture or as a product of reaction of an enzyme preparation made from the adapted cells acting on a preceding member in the reaction chain. Some comment on

the unified scheme presented in Table 1 is useful at this stage.

Pathways (1), (2), (3). Using *Vibrio* 01, Evans and Happold[4] isolated catechol from a culture growing on phenol media; with *p*-hydroxybenzoic acid as initial substrate, Evans[5] identified protocatechuic acid as one of the products. The course of the metabolism of benzoic acid proved more difficult to determine, since none of the monohydroxybenzoic acids appeared to be formed, neither did the three isomers obey the criteria of simultaneous adaptation. Stanier[6] provided evidence, by the latter technique, that the metabolic pathways of benzoic and *p*-hydroxybenzoic acids with his *Pseudomonas fluorescens* organism are initially separate and distinct. Almost simultaneously, Evans, Parr and Evans[7] isolated catechol from a benzoate culture of *Vibrio* 01. No known intermediate has been found to take part between these two compounds, and it appears probable that these organisms produce catechol from benzoic acid in a single oxidative reaction.

In the original biochemical work on phenol breakdown, Evans and Happold[4] and Evans[5] detected the transient formation of a keto-acid which gave a positive Rothera and Gerhart test, but which was not identical with aceto-acetic acid. This elusive intermediate was finally characterized by Kilby[8] as β-ketoadipic acid. Afterwards it was shown by Evans, Parr and Evans[9] that protocatechuic acid also gives rise to β-ketoadipic acid after ring cleavage. Whether β-ketoadipic acid is the immediate product of ring opening in pathways (1), (2) and (3) remained obscure until quite recently.

Pathways (5), (6), (7), (8). That mandelic acid is metabolized through benzoic acid by *Pseudomonas fluorescens* was established, through simultaneous adaptation, by Stanier[6]. Recently, Evans and B. S. W. Smith[10] have shown that *p*-cresol gives rise to *p*-hydroxybenzoic acid by its isolation from culture. Evidence has also been obtained by the latter workers indicating that phenylalanine and tyrosine undergo side-chain oxidation to *p*-hydroxybenzoic acid prior to ring cleavage.

Pathway (4). Suda, Hayaishi and Oda[11] studied the adaptive behaviour of *Pseudomonas* spp. in tryptophane metabolism. One of the significant results of their work was that this occurs through kynurenine and anthranilic acid, to catechol, this latter compound being further metabolized by ring fission. In fact, Hayaishi and Hashimoto[12] succeeded in purifying an enzyme system from these *Pseudomonas* spp. which they termed 'pyrocatecase', able to convert catechol to what was believed to be *cis-cis*-muconic acid. When, however, the substance isolated was tested by Stanier and Hayaishi[13] with a crude enzyme preparation which catalyses the reaction

$$\text{catechol} + O_2 + H_2O \rightarrow \beta\text{-ketoadipic acid},$$

it was found incapable of giving the keto-acid, a fact which excluded it from being a true intermediate in this reaction. The position, therefore, remained for a time rather puzzling.

At this stage the investigations of Elvidge, Linstead, Sims and Orkin[14] on the stereochemistry of the muconic acids threw light on the microbiological problem. These workers isolated a new *cis-trans*-muconic acid from the alkali-catalysed isomerization of a related unsaturated lactone. The new acid (m.p. 184° C.) resembled very closely the *cis-cis*-muconic acid which can be prepared by the chemical oxidation of phenol[15]. When the *cis-cis*-acid is merely boiled with water, it is inverted into the new *cis-trans*-isomeride. This means that many samples of '*cis-cis*'-acid used by previous workers must have been inverted by the usual processes of purification. Methods of identifying the two stereoisomerides and the proof of their configuration have been described[14]. It may be added that the configurations have recently been confirmed by semi-hydrogenation experiments (in which the *cis-cis*-muconic acid gives only *cis*-Δ^{α}-dihydro-muconic acid, whereas the *cis-trans*-acid gives both *cis*- and *trans*-Δ^{α}-dihydro-muconic acids)[16].

A difference between the acids is also clearly shown in the microbiological work as follows. The three muconic acids were examined as substrates by Evans and B. S. W. Smith[17]. These experiments showed that the bacterial enzymes which convert catechol to β-ketoadipic acid do so through the intermediate formation of the *cis-cis*-form of muconic acid (I). The enzymes show a rigid biological specificity in this respect, being without action on the other two geometrical isomers. These facts explain why the muconic acid isolated by Hayaishi and Hashimoto was not converted into β-ketoadipic acid by the appropriate enzyme system. In their process of isolation, isomerization of the *cis-cis*-muconic acid to the *cis-trans* form must have occurred. That this explanation is correct has been confirmed by Stanier and Hayaishi[13]. *cis-cis*-Muconic acid, however, does not appear to participate in pathway (3), but Stanier[18] has provided evidence of the formation of a tricarboxylic acid, possibly β-carboxy-muconic acid, in this pathway.

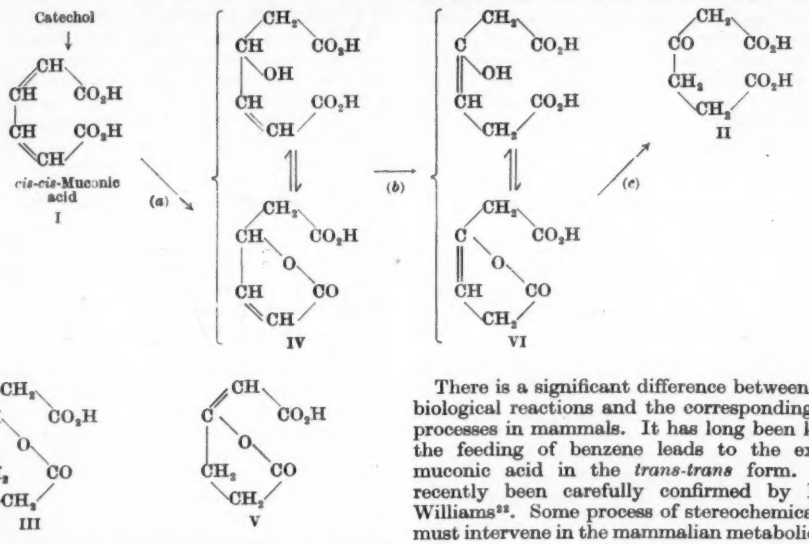
Attention has now been given to the possible intermediate stages between *cis-cis*-muconic acid (I) and β-ketoadipic acid (II), which is the common intermediary metabolite of the various substrates (1)–(8).

Using an enzyme preparation from catechol-adapted cells of *Vibrio* 01 and *Pseudomonas fluorescens* strains, it was first demonstrated manometrically that this reaction (I) → (II) proceeds quantitatively without the participation of molecular oxygen (the β-ketoadipic acid produced was estimated by measuring the carbon dioxide formed on decarboxylation with aniline citrate). This meant that no change was likely to occur in the oxidation-level of the metabolites, and this was confirmed by experiments in which adipic acid, and the saturated lactone (III) equivalent to β-hydroxyadipic acid, were incubated with the cell-free enzyme system. The formation of β-ketoadipic acid was tested for by the Rothera reaction and the ferric chloride reaction. None was formed.

TABLE 2. ACTION OF THE AROMATIC RING-SPLITTING ENZYME SYSTEM FROM CATECHOL-GROWN CELLS ON POSSIBLE INTERMEDIATES IN THE PRODUCTION OF β-KETOADIPIC ACID

Substrate (50 mgm. in 7 ml. M/20 phosphate buffer, adjusted to *p*H 7; 3 ml. enzyme solution)	Production of β-keto-adipic acid after: 15 min.	30 min.	60 min.
Catechol	+	+	+++
cis-cis-Muconic acid	+	++	++++
cis-trans-Muconic acid	–	–	–
trans-trans-Muconic acid	–	–	–
Protocatechuic acid	–	–	–
γ-Carboxymethyl-Δ^{α}-butenolide (IV)	++	+++	++++
γ-Carboxymethylenebutanolide (V)	–	–	–
Dihydro-lactonic acid (III)	–	–	–
Adipic acid	–	–	–

TABLE 3. MECHANISM OF THE CONVERSION OF *cis-cis*-MUCONIC ACID TO β-KETOADIPIC ACID BY THE AROMATIC RING-SPLITTING ENZYME SYSTEM FROM CATECHOL-GROWN BACTERIAL CELLS



β-Ketoadipic acid differs from muconic acid by the elements of a molecule of water. Addition of water to *cis-cis*-muconic acid would be expected to yield the β-hydroxy acid which could readily cyclize to the unsaturated lactonic acid, γ-carboxymethyl-Δ^{α}-butenolide (IV). This has recently been prepared by Elvidge, Linstead, Orkin, Sims, Baer and Pattison[19]. Another related substance at the same level of oxidation and hydration is γ-carboxymethylene-butanolide (V)[20]. Incubation experiments were accordingly carried out with these unsaturated lactones, β-ketoadipic acid being tested for by colour reaction and, in some cases, by isolation from the reaction mixtures.

The Δ^{α}-unsaturated lactone (IV) gave strong positive results, the isomeride (V) being negative. Table 2 summarizes these experiments, positive signs denoting the extent of appearance of β-ketoadipic acid. Control experiments on the substrate together with a boiled enzyme solution gave entirely negative results under the same conditions.

In summary, γ-carboxymethyl-Δ^{α}-butenolide (IV) is converted to β-ketoadipic acid, appreciably faster than is *cis-cis*-muconic acid, which is, in turn, faster than catechol. We therefore propose the reaction mechanism given in Table 3 for the missing stages in the total process.

The essential stages are (*a*) addition of water or isomerization; (*b*) migration of the double bond; (*c*) ketonization of the enol corresponding to the βγ-unsaturated lactone (VI). We do not know whether the tautomeric change (*b*) occurs between the open-chain hydroxy acids or their lactonic counterparts. The lactone (VI) is as yet unknown, but the overall changes (I) → (IV) and (IV) → (II) have been realized in purely chemical reactions (see ref. 19; also Kuehl, Linstead and Orkin[21]), making it highly probable that the scheme is essentially correct.

It is particularly interesting that the γδ-unsaturated lactone (V) is not an intermediate in the biochemical transformation (I) → (II), although both of the steps (I) → (V)[19] and (V) → (II)[20] have been effected *in vitro*.

There is a significant difference between the microbiological reactions and the corresponding metabolic processes in mammals. It has long been known that the feeding of benzene leads to the excretion of muconic acid in the *trans-trans* form. This has recently been carefully confirmed by Parke and Williams[22]. Some process of stereochemical inversion must intervene in the mammalian metabolic processes.

One of us (W. Charles Evans) is grateful to the Royal Society for a grant.

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INSTRUCTIONAL FILM RESEARCH IN PENNSYLVANIA

THE Pennsylvania State College Instructional Film Research Program, which is still in progress, exceeds in scope any previous research on the instructional film. It was begun in 1947, under the sponsorship of the Special Devices Center of the Office of U.S.A. Naval Research, and is now controlled by a Joint Services Advisory Committee of both the Army and the Navy. These Departments

are interested in securing improvements in the instructional film, because they use the film for training purposes. They are also anxious to discover how far the film may displace—rather than merely aid—a skilled instructor. But the research—in which a number of divisions of Pennsylvania State College are co-operating—is of a fundamental kind. The results being obtained are of importance to all who use or make educational films.

An account of the work is given in a series of reports issued by the Special Devices Center, Port Washington, N.Y.; application for which can be made to the director of research, Dr. C. R. Carpenter, Pennsylvania State College, U.S.A. (In preparing the present article the reports chiefly consulted were four Technical Reports S.D.C. 269-7-6, 9, 10, 13; two Progress Reports 11-12, 14-15-16; Incidental Report No. 1; and Special Report No. 2.)

A general method of experimentation has been to produce different versions of a film, and to show them to matched samples of an appropriate audience. Tests, either of the objective multiple-choice question type or of actual performance, are then used to determine the relative teaching effectiveness of the versions. The films used in the experiments have been sound films, predominantly of the commentary-picture type.

Some of the main conclusions so far reached may be characterized as confirming previous opinion. The need for limited and specific objectives in instructional films is much stressed. The rate of development (that is, of putting forward new facts and ideas) of most present-day instructional films is too fast. Good projection and related conditions are of prime importance.

Many of the conclusions are on matters of technique about which, without details of the Pennsylvania experimentation, it would be impossible to form an opinion. In teaching a manipulatory task, the view given should as nearly as possible correspond with that of the learner in performing the task. There is an optimal level for the amount of verbal explanation (found to be about a hundred words a minute for the films used). To establish learning points, commentary should usually be in advance of the picture. The imperative form of address appears the most effective, and the third person passive least effective. There is no advantage in colour, except where it supplies determining learning cues, nor in background music for films of the commentary-picture type. Educational film sessions can last up to one hour with no decrease in effectiveness of teaching. The prestige attached by an audience to the principal exponent in a film increases the influence of the film on attitudes and factual learning from the film. Visual or sound attention-gaining devices, which are themselves irrelevant to the subject-matter, are no advantage.

The most provocative conclusion derived from the experiments is perhaps the one which states that a body of factual information can be taught as well by films alone as by standard lecture – text-book methods. This would seem to imply that films in some circumstances may displace the teacher in the classroom or lecture theatre in a more far-reaching sense than has formerly been realized, and for longer periods. But the Pennsylvania conclusions also make clear that an indispensable part is played by the teacher in 'face-to-face leadership'.

C. Denis Pegge

FILARIASIS IN THE PACIFIC

What should be regarded as an important step forward in the welfare of the Pacific region and the very varied races that populate its myriad islands has been the creation of a South Pacific Commission with representatives from the widely scattered peoples of this area. The first conference of this newly constituted international body met in Suva during April and May 1950, under the presidency of the Governor of Fiji, Sir Brian Freeston. On the recommendation of this conference a congress in Tahiti of experts on filariasis and elephantiasis was arranged, and met during August 21–September 1, 1951, under the presidency of the Governor of French Oceania in the meeting room of the Representative Assembly at Papeete. Dr. E. Massal, a member of the South Pacific Commission, was elected chairman.

The proceedings of the congress have appeared, with commendable promptitude, in some twenty-two typewritten double-sided sheets. If the nature of the headings and the abstracts of the proceedings are any measure of the labours of this congress, then certainly it must be confessed that an immense amount of work was accomplished. It is gratifying to note that, taking part in the congress and thus adding to its international character, were representatives from Oceania as well as from France, the United States, New Zealand and Australia.

The work of the congress was divided under a number of headings. Under parasitology it was agreed to consider the local filaria as the Pacific variety of *Wuchereria bancrofti*, as suggested originally by the reviewer, and it was regarded as essential that the minute morphology of the adult stages should be worked out, that studies should be undertaken on the longevity of this parasite and its intermediate immature stages in the human body, and that a review of periodicity throughout the Pacific should be made. Under entomology, a paper on the mosquito vectors of human filariasis in Oceania was read by Dr. L. Rosen, of the School of Medicine, University of California, paying special attention to the *scutellaris* group of *Aëdes* with particular reference to *A. horrescens*. A film on the filariasis control programme in Tahiti was shown. It was further urged that experimental studies on mosquitoes in each area should be made to determine their potentialities as vectors of *Wuchereria* with special reference to the ability of *W. bancrofti* to develop in *Culex fatigans* in Polynesia and Melanesia. Dr. E. R. R. Brygoo, director of the Institut Pasteur, Saigon, presented a paper on the epidemiology of filariasis in the South Pacific, in which the example of New California was adduced, where neither Anopheles nor the *scutellaris* group of *Aëdes* are found, but where filariasis is widespread. The possibility of *W. malayi* being present in New Guinea was raised. The value of intradermal diagnostic tests was discussed, and the result obtained in Tahiti, Fiji and New Caledonia was compared with indefinite results. A new flocculation test was demonstrated by Dr. W. H. Wright, chief of the Laboratory of Tropical Diseases, National Institutes of Health, Bethesda, United States.

Under the heading of clinical pathology, Dr. P. E. C. Manson-Bahr, physician-specialist, Fiji, read a paper in which he proposed a conception of the infection occurring in three manifestations—primary or allergic, secondary or carrier state, and tertiary or obstructive; and it was agreed that this should form

a working basis and that further investigations into the exact mechanism of elephantiasis should be carried out. Under treatment, Dr. W. H. Wright stressed the inadequacy of information of the lethal action of 'Hetrazan' on the adult worms. The role of anti-histamine drugs and antibiotics, such as penicillin, was discussed. The control and prophylaxis of bancroftian filariasis in the South Pacific was in the hands of Dr. H. K. Beye, field director of the Pacific Tropical Diseases Foundation, University of California, who cited instances where mosquito control had resulted in decrease in the microfilaria rates. Present observations relating to mass drug therapy and mosquito infection rates indicated that the most effective procedure is to keep the blood permanently free of microfilariæ. Dosage schedules of 'Hetrazan' now under investigation give promise of meeting this object. The value of educational and other measures was discussed. Especial importance was paid to the training of native personnel in filariasis control. The subjects of standardization and procedures regarding blood examination and documentation had universal support. Standard methods of recording mosquitoes or their larvæ, the laboratory diagnosis for microfilariæ, the recording of clinical manifestations and standards for intradermal tests were agreed upon.

An annotated bibliography of filariasis is being drawn up especially as regards the South Pacific. Finally, it was decided to publish the final report of the conference as a public document.

As the original work on filariasis in the Pacific was undertaken by a member of the staff of the London School of Tropical Medicine in 1910, and as his results were reinforced and expanded later by O'Connor, Prof. P. A. Buxton and others, it is a considerable source of satisfaction to record that, not only has their work been confirmed, but also that it is now being placed upon a practical basis, so that this, the chief scourge of the Pacific, may soon be eliminated altogether. PHILIP MANSON-BAHR

THE ANCIENT KHMER EMPIRE

AN entertaining and scholarly history of the Khmer Empire from the first to the fifteenth centuries, entitled "The Ancient Khmer Empire"*, has been written by L. P. Briggs. The data are derived from Chinese dynastic histories and Oriental travellers' accounts; Sanskrit and Khmer epigraphy; Buddhic and Brahmanic iconography; architecture, art and sculpture; bas-reliefs; and excavations.

Three periods are distinguished: the Funan (first to sixth centuries); the Chenla (sixth century to 802); and the Kambuja or Angkor (802–1431). The Funan period is that of a small kingdom on the Melkong delta, inhabited by a people who may have had negrito racial elements and have spoken a pre-Khmer Austro-Asiatic language. They are believed to have been conquered in the first century by a foreign invader (possibly Malay) who married their queen and introduced clothing among their women. Direct relations with India and China date from the third century. An Indian Brahman is recorded to have become king of Funan in the fifth century, and to have introduced, among other customs, state worship of the Siva-linga and a Central Indian alphabet.

Funan was conquered and became a vassal kingdom of Chenla to the north in 550, the Chenlas being a Mon-Khmer people who had obtained their own kingdom by an earlier conquest of the Chams. The Chenla people were already acquainted with the Siva cult and with the Sanskrit Puranas and Epics. The united kingdom of Chenla and Funan was temporarily conquered by the Malays some time in the eighth century.

The Kambuja period opens with a line of kings who considered themselves incarnations of Siva and who founded a Devaraja cult, each new king being appointed by the head of a family of Brahman *purohitas*, among whom, unlike the rest of the population, descent was matrilineal. This was the classical period of Cambodian history, marked by a great expansion of the empire, a magnificent flowering of architecture and art, and a unique syncretism of Saivism, Vishnuism and Mahayana Buddhism. With the increasing influence of Buddhism, the Devaraja cult gave place to the cult of a Buddharaja. There was a decline in art and architecture in the thirteenth century, probably coincident with the introduction of Hinayana Buddhism. The period ends with the Siamese sacking of Angkor in 1431, and the removal of the capital to the south-east part of the kingdom. Though the Khmers gave to the world no system of administration or ethics, no literature and no philosophy, their civilization saw the summit of Oriental architecture and decoration.

KATHLEEN GOUGH

FOREST RESEARCH IN SWEDEN

VOL. 39 of the memoirs of the Forest Research Institute of Sweden* contains a number of articles of varied interest. Erik Holmsgard discusses height increment, development of the crown, self-pruning, etc., in young beech stands. His investigations seem to show great variations in height increment in various years, and this does not necessarily depend upon changes in climate; thus, the highest trees in a young stand will not necessarily remain so. The growth in height of the lateral branches and the height increment of the lower trees are more influenced by the light conditions than by the climate. It is impossible to give here the author's detailed conclusions, for which the paper should be consulted.

Henrik Petterson deals with the application of the new forestry conservation law passed in 1948, which aims in general at economic forest utilization with a constant yield. Mr. Petterson admits that it may seem futile under present conditions, when the outlook is so uncertain, to attempt to direct the utilization of forests toward an economic goal. The law differentiates between well-grown forests and those which are badly grown or tended: the former, apart from thinnings, may not be clear-felled without the consent of the Forest Conservation Bureau; and the latter must not be treated in such a manner as to result in further deterioration. Further, such measures must be carried out as will result in an improvement of the stocking of the forest within a reasonable time. The paper discusses the methods by which the law can be carried out. There is no indication

* "The Ancient Khmer Empire." Pp. 295, with 17 maps and 58 figures. (*Trans. American Phil. Soc.*, **41**, Part 1; 1951.)

* Meddelanden fran Statens Skogs-Forskningsinstitut, Band 39, 1950–51 (Stockholm, 1951).

that it proposes anything quite so drastic as the dedication scheme envisaged by the Forestry Commission in Great Britain.

A third paper of interest, by Marianne Lekander, treats of the invasions of insect pests in the Swedish forests during 1741–1945. The author has studied the whole of the literature—the forestry and entomological, administration and departmental reports of the State and reports of forestry conservators and the institute of research—and the paper appears to be an admirable piece of work. Mass invasions or slighter ones occurring more often are classified for each species of insect in a chronological order and are given for each of the forest conservancies in each province. A tabular statement is given at the end of the paper enumerating the chief pests of the forests during a period of fifty years, 1896–1945. An alphabetical list of the insects mentioned is given in Latin and Swedish.

Another paper, by Lars Tiren, is "On Clearing Spruce and its Significance for the Reforestation of Spruce Forest Clearings in Northern Sweden". The main objective was to study the nature and abundance of the seed and resulting seedling growth occurring from the spruce trees left standing in the forests in northern Sweden, and a good opportunity occurred in the good spruce seeding year 1942–43. In these northern spruce forests the future crop largely depends upon the poor type of tree called 'clearing spruce' or 'remnant spruce'. Even though these trees often appear very insignificant and inefficient for the purpose required, they do in effect function as seed-bearers, though often assisted by contributions from any forest border trees surrounding them. Briefly, the study has shown that some artificial help can assist, which may consist of raking under the trees or burning under them, providing a sufficiency of good trees remains to assist the others. Much further research requires to be carried out, which should prove of value to other parts of the world where forests growing under the same type of conditions exist.

CHEMICALS IN FOOD

THE United States Congress established in June 1950 a Select Committee, known as the Delaney Committee, which was given the task of assessing the dangers to public health arising from the increasing use of chemical substances in food manufacture and from the presence in foods of residues from the pesticides now widely employed in agriculture. This Committee has issued its preliminary findings* together with a full report† which is an important document embodying in its eight hundred pages the views of some seventy scientific workers, physicians and industrialists who appeared as witnesses.

The Committee heard the striking evidence submitted by the officers of the Food and Drug Administration, who stated that 704 extraneous substances were thought to be in use; of these, only 428 were considered harmless as normally employed, leaving a further 276 of which the safety was open to question. Attention was directed to a conflict of opinions regarding the suitability of various compounds. There are several which were at one time considered harmless and which found a place among food ingredients; later investigations established their toxic character. In this category are *p*-phenetyl urea, used for more than fifty years as a sugar substitute; chloracetic acid, a preservative for wines; and thiourea, an anti-browning agent for fruits. The dyestuff butter yellow served for many years as a food colour before its carcinogenic action was recognized, and lithium chloride was considered safe until it was shown to be fatal to persons living on a low salt (sodium chloride) diet.

The above substances are no longer employed, but there are others in use which are the subject of controversy; and although those materials which act as preservatives, anti-oxidants and mould inhibitors are added to food in very small quantities, others such as the synthetic emulsifiers used in the United States baking industry may be present in considerable amounts. Many witnesses pointed to the dangers that could result from the incorporation of these newer ingredients in a staple commodity such as bread.

Consideration was given not only to those substances which are added deliberately to foods to produce some desired effect, but also to others which may become associated with foodstuffs by accident. Among these are the surface-active agents employed in the cleaning of food utensils and machinery, and the pesticides, such as DDT, which may adhere to crops and find their way into foodstuffs. The very properties which make these substances so effective in the control of lower forms of life may lead to their absorption by plant tissues and to their injurious effects on higher animals.

Testimony was given regarding the difficulties experienced in devising suitable methods for the accurate estimation of many of the newer synthetic substances, especially at the low levels at which they are likely to occur in foods. Sound practical analytical methods are essential if there is to be adequate control of the degree of contamination of foods and if the pharmacological properties of the compounds are to be investigated.

Many scientific workers stressed the necessity of carefully designed toxicity studies. They pointed out that, in the past, the main emphasis had perhaps been on acute toxicity tests to discover the levels at which a substance would produce deaths in experimental animals within a short period of time after it had been given by mouth or by injection. In the light of experience gained over the past decade more detailed investigations are required—feeding experiments at different levels on several species of animals over a period of perhaps two years, together with a thorough study of the metabolism of the substance under discussion, its effects on the tissues of the experimental animals and its relation to growth, reproduction and lactation. The results of some of these *chronic toxicity* studies were quoted; there were substances which appeared to be harmless in short-term experiments—in that they did not cause death immediately following ingestion—yet small amounts accumulated in the body and ultimately produced permanent injury.

Experiments on the chlorinated hydrocarbon DDT were described which demonstrated that DDT appeared in the flesh of chickens, cows and sheep which had eaten crops sprayed with the pesticide. It was present also in eggs and in milk. Moreover,

* Investigation of the Use of Chemicals in Food Products. 1951. Union Calendar No. 1139. Report No. 3254. (U.S. Gov. Printer, Washington, D.C.)

† Chemicals in Food Products. Hearings before the House Select Committee. 1951. (U.S. Gov. Printer, Washington, D.C.)

lactating cows in a byre treated with DDT secreted in the milk within forty-eight hours quantities of 2 parts per million. This amount was shown to be significant in that DDT when fed to laboratory animals was stored in the body fats; diets containing as little as 5 parts per million produced liver injury in rats. Other pesticides are even more highly toxic, and it was suggested that some should be banned completely from use on food crops.

Many other topics were reviewed by the Delaney Committee; for example, the impairment of the nutritive value of prepared foodstuffs through the replacement of naturally occurring constituents such as fat by synthetic materials which cannot be utilized by the body and which may interfere with the normal absorption and metabolism of nutrients. Information was also given regarding the unforeseen consequences of the introduction of synthetic hormones into poultry husbandry; mink fed on the offal of chickens treated with hormones became sterile, an observation which has naturally led to a demand for a full inquiry.

There is now a substantial body of public opinion in the United States which favours legislation to deal with the various problems outlined above, and this proposal is supported by members of the medical profession and by others working in the fields of biochemistry and nutrition. The central issue under discussion is how to frame suitable legislation which, on one hand, will provide adequate protection for the consumer and, on the other, will also give freedom for new and legitimate developments in agriculture and food technology.

FRANCIS AYLWARD

MECHANICAL ENGINEERING RESEARCH ORGANIZATION

REPORT FOR 1947-50

UNTIL recently it was clear that in Great Britain research in mechanical engineering suffered from lack of any central co-ordination: a considerable amount of work was being done in government, industrial and university research laboratories, but in some branches the researches carried out were insufficiently fundamental, being directed towards the solution of immediate problems. A new organization was clearly needed, both to conduct basic research not carried out elsewhere and to serve as a focal point for all other research work. To meet this need the Mechanical Engineering Research Board was appointed in 1946 to advise on the organization and equipment of the government-sponsored Mechanical Engineering Research Organization, to which funds amounting to some £300,000 a year were allotted.

The first report of the director of the Organization has now been issued*. It is prefaced by a report of the Board, which reviews the broad issues involved and the progress achieved in the establishment of this new Organization. It gives a clear and concise account of the whole situation: the objectives, the resources available, the constructional work complete or projected, the research now in hand or planned, and the collaboration with other research bodies.

A new organization of this type cannot grow without any roots: it is necessary to train the teams who will work together, before they can be transplanted to other premises. There must be a proportion of well-established lines of research in addition to those that are quite new. In this case the greatest debt is to the Engineering and Metrology Divisions of the National Physical Laboratory, from which the nucleus of the Mechanical Engineering Research Organization has been formed.

It was decided, on broad national grounds, that the new laboratory should be situated in Scotland. The site adopted is at East Kilbride, near Glasgow, together with temporary premises a few miles away at Thorntonhall, and sufficient laboratories and essential services are now ready at East Kilbride for research work to begin there. The establishment is being organized into seven main divisions, the work of each being under the supervision of a committee of experts from industrial and other research laboratories. In addition, a considerable amount of extra-departmental research is being undertaken in collaboration with each division.

The first director of the Organization was Dr. G. A. Hankins, formerly superintendent of the Engineering Division of the National Physical Laboratory. Since his death in November 1950, Dr. D. G. Sopwith, his successor at the National Physical Laboratory, has been in charge on a part-time basis (see p. 769). His report gives a fairly complete picture of the work done during the first three years of the existence of the Organization. In the early stages the main emphasis was naturally on the formulation of future research programmes; this changed to the detailed design of laboratories and equipment and the recruiting and training of staff. The total staff in 1948 numbered only seventeen, but by December 1950 the scientific and technical staff had increased to sixty-three, together with a roughly equal number of ancillary laboratory, office and industrial staff.

The progress of the various researches and future work planned by each division is detailed, together with an account of extra-departmental projects. Even an outline of all the work undertaken or contemplated is impossible in this article. It ranges from the comparatively familiar tests and techniques used in the testing of materials to the development of the use and analysis of mechanisms, a branch of engineering science which has remained practically static for some fifty years. It is apparent how closely allied many of the researches are to other fields of scientific, as opposed to technological, research; it is, of course, quite impossible, and undesirable, to make any such distinction. It is intended, however, that the work of the Organization shall be carried through to the development stage, should it be considered essential to do this in order to make apparent the industrial advantages to be gained from the results of basic work.

This publication is likely to prove of interest to those engaged in scientific research of any sort, and it can be recommended as giving a clear idea of the progress and aims of the new venture. No longer can it be maintained with justice that technological research in Great Britain lags behind general scientific research, either in relation to its fundamental nature or to the breadth of outlook of those concerned with it.

R. H. MACMILLAN

*Department of Scientific and Industrial Research. Report of the Mechanical Engineering Research Board, with the Report of the Director of Mechanical Engineering Research for the Period May 1947 to December 1950. Pp. 39+8 plates. (London: H.M.S.O., 1951; 2s. 6d.)

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Existence and Nature of the 'Positive Particles' near a Source of Radium E

We have recently taken two thousand pairs of photographs of the cloud-chamber tracks of particles emitted from radium E. The rays entered through a small aperture from a source situated outside the chamber, across the centre of which was stretched a foil of aluminium of mass 0·046 gm./cm.². The applied uniform magnetic field was about 220 gauss, and almost all the tracks showed a curvature indicating a negative charge. In a total of some 12,000 tracks, not more than twenty were found which proceeded from the source and which had a curvature in the opposite direction from that of the negative β-particles. Applying further very rigorous criteria of perfection, we can select three tracks A, B and C, of which A and B have $H\rho$ about 2,400, while the value for C is the highest recorded at 3,600.

It may easily be shown by the application of the conservation laws of energy and charge in the radium E→radium F transition that there is insufficient energy for positron–electron pair production with the observed momenta. Proceeding systematically to consider the values of e and m which would satisfy the observed values of $H\rho$, the available energy in the radioactive transformation and the conservation of charge, the remarkable fact emerges that the observations are plausibly satisfied only if $e = e_0/2$ and $m = m_0/2$ or zero, where e_0 and m_0 are the electronic charge and mass. The former particle would have e/m identical with that for an electron and would be indistinguishable from it in several qualitative aspects. Now particle A fails to appear on the other side of the foil, and in this respect it corresponds to the observed behaviour of many of the negative β-particles of similar $H\rho$. On the other hand, particle B appears to traverse the foil with little loss in energy, which is what might be expected for a particle with the high kinetic energy to be associated with a particle of zero rest mass. These ideas have been applied to the examination of earlier results obtained by other workers in this field and consistent results are obtained.

However, apart from their feeble intensity, it still remains very difficult to explain why such particles have not been detected by a conventional 180° β-ray spectrometer, since the action of the latter depends only on the values of $H\rho$ as a measure of the momenta of the particles, and is independent of the particular values of e/m. Further consideration of our photographs shows that, while the probabilities are remote, it is still possible to explain the 'positive tracks' without the introduction of any particles other than the negative β-particles. Particle A could be due to a scattered negative β-particle which has been deflected through about 140° just before reaching the foil, for in earlier work on large-angle scattering of fast β-particles by nitrogen nuclei, one such deflexion occurred in a similar total length of track. It must be pointed out, however, that to satisfy the experimental observations, not only is a scattering angle of this magnitude required but, in addition, the scattered particle must proceed directly towards the source in the plane of the chamber throughout its entire length. There is also the grave difficulty that the track, which might correspond to the parent before scattering, is seen to be in a different plane from the scattered track.

Since the source was situated outside the chamber, the chances of radioactive contamination were reduced to a minimum, although it was not completely absent. With regard to particle B, the two portions of the track which appear on each side of the foil could arise from independent events where one track originates from contamination on the chamber wall and proceeds to the foil, while the other could come from contamination on the foil itself (at the identical spot and at the same time as the first track) and then proceed to the source. The two tracks would have to be of about equal momenta and to proceed in the same direction at the foil. The chance of all these conditions being satisfied simultaneously appears utterly remote, even bearing in mind the fact that the momentum involved in these cases is, in fact, that corresponding to the most probable momentum of the negative β-particle spectrum. On the other hand, it can be shown on plausible grounds, based on the fact that the most probable β-particle energy is about one-third that of the upper limit of the β-particle energy spectrum, that this $H\rho$ is also the most probable value likely to occur if the existence of the new particles were real.

In view of the work already done, together with the present results, it seems unlikely that more cloud chamber experiments of this type will throw further light on this extraordinarily elusive problem; but it would be interesting to use other techniques for detecting the existence of these 'positive particles' now that the present work has suggested possible values of mass and charge. There does not seem less evidence for the reality of their existence than exists for the neutrino at present.

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An Experiment on Nuclear Alignment: the Anisotropy of γ-Radiation from Oriented Cobalt-60 Nuclei

Radiations from radioactive nuclei oriented at random are isotropic; but if the nuclei are even partially aligned, an anisotropic distribution should in general be found provided I is greater than $\frac{1}{2}$, as shown by Spiers[1]. In order to align nuclei, one makes use of the energy differences between the various orientations of the nuclear spin. By cooling to low enough temperatures, the lower levels will be preferentially populated, and in suitable systems this corresponds to a spatial alignment. In general, these energy differences are so small that temperatures obtainable only by adiabatic demagnetization must be used.

Besides the obvious and quite general method for producing these energy differences by an external magnetic field[2], the following more specific mechanisms have been suggested: by interaction between the nuclear electric quadrupole moment and the crystalline field (Pound's method[3]), or by the magnetic interaction between the nuclear spin and the resultant magnetic moment of the electrons in a paramagnetic ion. In this latter case the electronic moments must first be aligned, and this may be done either by a small external magnetic field (Gorter–Rose method[4,5]), or through the inter-

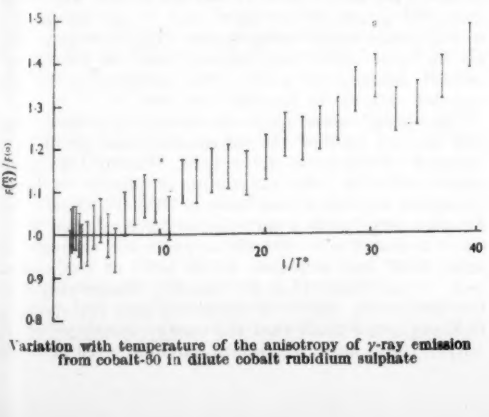
action of the electrons with the crystalline field (Bleaney's method[6,7]). Gorter, de Klerk, Poppema, Steenland and de Vries[8] carried out preliminary experiments using the Gorter–Rose method on the γ-emission from iron-59, and on neutron absorption in gadolinium, but inconclusive results were obtained. Thus, in the case of iron-59, only one experiment is reported to have given an anisotropy, which, however, was only 2 per cent with an experimental error of 1 per cent.

In the experiments which we report here Bleaney's method was used. The substance was a mixed Tutton salt with the composition (1% Co, 12% Cu, 87% Zn) $SO_4.Rb_2SO_4.6H_2O$. Copper acted as cooling agent, zinc as a non-magnetic diluent to reduce magnetic interaction and rubidium was chosen as monovalent cation so as to reduce exchange interaction[9]. This enabled us to attain a lower temperature than would have been possible with a concentrated salt, namely, about 0·02° K. from an initial H/T of 30,000 Oe./°.

Six single crystals of a total weight of 4 gm. containing about 70 microcuries of cobalt-60 were mounted in a demagnetization cryostat with parallel crystallographic orientation, and the K_1 and K_2 axes (two of the principal axes of susceptibility) in a horizontal plane. The γ-radiation was detected by four Geiger counters (G.E.C. Type *GM4*), two each along the K_1 and K_2 axes of the cobalt ions, placed at 10·5 cm. from the centre of the specimen and subtending an angle of 13°.

The counting-rate was taken for successive 10-sec. periods while the specimen warmed up, and, at the same time, readings were taken of the magnetic susceptibility of the specimen. It was necessary to use short measuring times because the specimen remained at a low enough temperature for about five minutes only. This was on account of the very small thermal capacity of the salt, and of the heating-rate of some 150 ergs/min., composed of the self-heating due to the radioactivity of the crystals, and of a small heat leakage. Frequent tests showed that the counters were stable, and that the counting-rates followed the normal statistical distribution; this has been assumed in evaluating the probable error of individual measurements. The number of counts observed in a particular 10-sec. period was normalized to the mean counting-rate obtained in the same counter when the specimen had warmed up to 1° K. This figure for each particular counting period was averaged with respect to the two counters on the same axis, and is denoted by F.

The axes of alignment (that is, the tetragonal axes of the crystalline field, there being two ions in the unit cell and hence two alignment axes) are perpendicular to the K_3 axis, and each makes an angle α (= 37·5° in cobalt rubidium sulphate[10]) with the K_1 axis, that is, with the horizontal plane[7]. Accordingly, the two values of F are denoted by $F\left(\frac{\pi}{2}\right)$ and $F(\alpha)$ respectively. Altogether, thirteen demagnetizations have been carried out on four different days under different experimental conditions, and all gave consistent results. Anisotropies of up to 44 per cent were observed, and the result obtained from one demagnetization which gave the maximum effect is shown in the accompanying graph, where $F\left(\frac{\pi}{2}\right)\Big/F(\alpha)$ is plotted against $1/T^*$. The 'magnetic temperature' T^* (defined by means of Curie's law) is not very different from the absolute temperature for this substance.



Variation with temperature of the anisotropy of γ-ray emission from cobalt-60 in dilute cobalt rubidium sulphate

In order to eliminate any effect due to individual counters, the experiments were repeated with the pairs of counters interchanged. It was also shown that the observed effect was not due to extraneous magnetic interference, because, on carrying out several demagnetizations starting from higher temperatures which resulted in little or no cooling, no anisotropy was observed.

The maximum effect observed by us, namely, $1·44 \pm 0·05$, is, judging from the shape of the curves and knowledge of the entropies, unlikely to be the saturation value. In comparing our values with theory it must be borne in mind that Spiers's discussion relates to γ-emission from aligned nuclei. In our experiment it is the cobalt-60 nucleus which is aligned, whereas the γ-radiation is emitted by the daughter nucleus nickel-60 formed by β-decay. If this β-transition from cobalt-60 to nickel-60 is accompanied by a change of angular momentum, the alignment may be partially destroyed. This has been discussed by Steenberg[11], who showed that no great reduction in the anisotropy of the γ-rays was to be expected for the possible angular momentum changes involved in the cobalt-60 β-decay. The maximum value of our effect is consistent with the saturation value predicted by Steenberg (1·6–1·7, according to the nature of the β-transition).

This experiment would not have been possible without the guidance and co-operation of Dr. N. Kurti and Dr. H. Halban. We wish to thank also Dr. B. Bleaney for stimulating discussion, and Prof. F. E. Simon for his continued advice and encouragement. Acknowledgment is due to the Department of Scientific and Industrial Research for generous help which made this research possible.

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Oxford. Oct. 16.

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Detection of Circularly Polarized γ-Rays and the Production of Polarized Electrons

In a recent communication[1], it was pointed out that the $(n - \gamma)$ processes induced by polarized neutrons will in general lead to partially or totally polarized end-products. In particular, it was shown that for spin values of the initial and resulting nucleus of 0 and $\frac{1}{2}$, respectively, the γ-ray emitted in the direction of the spin of the incident neutron is completely circularly polarized. The same result holds true for the pair of spin values $\frac{1}{2}$, 0.

I wish to report now on some simple results concerning possible experiments with circularly polarized γ-rays. Choosing a special case of the Compton effect in which the quantum is scattered backwards and the electron forward in the direction of incidence, one finds that for moderately large quanta $\left(\frac{h\nu}{mc^2} \gtrsim 3\right)$ and an unpolarized electron initially at rest, the scattered electron is almost totally polarized, its spin pointing in the direction of propagation.

Similarly, if the electron is initially suitably polarized, the scattering cross-section will vary (in the approximation used) between zero and twice the value obtained for an unpolarized electron.

A detailed discussion, including that of other interactions between γ-rays and electrons, will be published in the *Physical Review*.

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The Helix as a Linear Accelerator for Protons

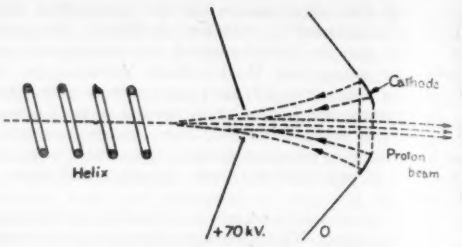
An electrostatic generator, designed for 4 MV., has been built at this Laboratory to accelerate positive ions, and the possibility of increasing the energy of protons from this machine to about 20 MeV. by means of a linear accelerator has been considered.

The disk-loaded wave-guide type of linear accelerator used for electron acceleration is impracticable for protons in this energy-range on account of the low phase-velocities required (0·1–0·2*c*). The high-frequency losses would be prohibitive and the tolerances in dimensions impossible to meet.

A more practicable form of proton accelerator is that suggested by W. Walkinshaw[1], consisting of a circular wave-guide made up of a closely wound helical wire. Roughly, the travelling wave tends to follow the wire and is slowed down in the ratio of the pitch to the circumference of the helix. More accurately, the phase-velocity can be calculated from an approximate field solution given by Pierce and Schelkunoff[2].

In a proposed design, assuming the helix radius to be 1 cm., the optimum free-space wave-length is found to be 1 metre. If the radio-frequency power flowing down the guide is 2 MW., an accelerator 11 metres long will accelerate the protons from 4 to 20 MeV. The power dissipated in the helix is 380 kW.; the remainder can be fed back from output to input through an external line and suitable phase-correcting network.

The chief difficulty in principle arises from the defocusing effect of the wave on the proton beam.



Possible arrangement of electronic gun

Those protons which get caught up by the wave and accelerated with it oscillate slowly about a stable phase-point which lies in front of the peak of the axial field; that is, in the region where there is a radial component of electric field outward. This radial component would cause a proton beam of initial radius 1 mm. to spread and touch the helix in a distance of about 1 metre.

It is suggested that this may be prevented by sending a beam of electrons along the axis of the guide, in the opposite direction to the protons for convenience. The beam would be launched by some form of annular gun through which the proton beam could pass. The space charge per unit length of the electron beam must be sufficient to create a radial electrostatic field inward, equal to the maximum outward field arising from the wave. The energy of the beam must be such that no electrons are turned back by the wave at any point along the guide or at any phase of entry. Simple calculations indicate that a beam of 1 amp. at about 70 kV. is required. The electron gun may be pulsed in synchronism with the radio-frequency oscillator in order to ease problems of heat dissipation and X-ray intensity. An electron gun has not yet been designed, but the accompanying diagram suggests a general arrangement of electrodes at the output end of the helix.

It is further suggested that the spreading of the electron beam under its own space-charge forces may be prevented by applying an axial magnetic field along the guide by means of a long solenoid. The electrons then acquire a cycloidal component of motion in a plane normal to the axis, similar to the motion in a cylindrical magnetron. Assuming the initial radius of the beam to equal that of the proton beam (1 mm.), and using the magnetron cut off equation, one can calculate the magnetic field required to prevent the beam radius from exceeding the value needed to keep the proton beam properly focused. Values obtained in this way range from 870 gauss at the input end of the accelerator to 570 gauss at the output end. The divergent field at the open end of the solenoid may be used, with careful design, to guide the electrons from the annular cathode in towards the axis.

The spread of energy in the emerging proton beam will depend on how far the stable phase-point is in advance of the peak of the field. Taking this phase angle to be 35°, the maximum amplitude of phase excursion a particle can have is 70°. The maximum kinetic energy such a particle can have relative to the wave is that due to this phase excursion through the axial field, and amounts to 50 keV. at the output end. Converting this to velocity, transforming to the laboratory frame of reference, and reconverting to energy, one finds that the energy spectrum of the output beam has a maximum value of ± 10 per cent,

or approximately ± 7 per cent at half amplitude. This spread can be reduced by reducing the angle of the stable phase-point, with a corresponding reduction in number of protons caught up per cycle by the wave, and hence in the mean output current.

We wish to thank Messrs. R. L. Fortescue, W. W. Walkinshaw and J. S. Bell[3] for valuable discussions and suggestions in connexion with this work, and we are indebted to Dr. T. E. Allibone for permission to publish this communication.

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Polymorphism arising from Screw Dislocation

Frank[1] predicted from theoretical considerations that crystal growth may proceed owing to the presence of screw dislocations. Spiral growth-steps confirming these ideas were observed by Griffin[2] in beryl crystals and by Dawson and Vand[3] in *n*-paraffin crystals. The dislocation responsible for the growth of a crystal may be described by means of a Burgers vector. For a simple screw dislocation, this vector is one structural unit in length and perpendicular to the growing face, so that a spiral growth-step one unit in height is generated. In a certain number of cases the Burgers vector is several units in length, the original length being determined by the detailed shape of the primary nucleus or other accidents of growth.

In many layer structures, several kinds of stacking having nearly equal energies are possible, the best-known example being the cubic and hexagonal stacking of layers of spheres. If the crystal grows by successive deposition of fresh layers, then a random disorder in the succession of the layers would result. However, if the crystal grows by means of a screw dislocation, then it consists of a single sheet spirally wound around the screw dislocation, the pitch of the screw so formed being equal to the Burgers vector. When the growth-sheet is several packing layers thick, any original packing mistakes in the sheet would repeat themselves throughout the crystal with the periodicity of the Burgers vector. Crystals so formed may be regarded as exhibiting polymorphism, the particular polymorphic form being defined by its unit-cell dimension and the arrangement of the stacking within the unit cell.

In order that this type of polymorphism could be observable, the following conditions must be fulfilled: (*a*) more than one possibility of stacking of layers should be available; (*b*) the crystal growth should proceed by means of screw dislocations having a Burgers vector more than one structural unit in length; (*c*) the screw dislocation system should be stable, that is, the Burgers vector should remain the same throughout the growth of the crystal.

If the last condition is not fulfilled, then twins or multiple intergrowths, each in a different polymorphic form, would result.

It is possible that this type of polymorphism may be quite widespread in Nature. The best example is that of silicon carbide, which is known to exhibit a wide variety of polymorphic forms. In silicon carbide, the screw dislocations must be very stable, as large crystals all in the same polymorphic form occur. Another substance which shows this type of polymorphism is graphite; but, owing to its softness, its polymorphism can be studied only on very small crystals. A more detailed discussion will be published elsewhere. I wish to thank Prof. J. Monteath Robertson for his interest, and Drs. I. M. Dawson and F. C. Frank for valuable discussion.

Note added in proof. In a recent paper, Frank[4] has advanced a similar explanation of polymorphism (polytypism) of silicon carbide.

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Growth Spiral Patterns on Carborundum Crystals

Observations on growth spirals on carborundum crystals have been reported earlier[1], affording experimental evidence of Frank's theory of crystal growth depending upon dislocations. Some new and unpredicted features of these growth spirals are reported here.

In Fig. 1 is shown part of an interlaced spiral in which in any one orientation *seven* steps are seen to group together. On following these steps to the other side of the interlaced portion, the same sequence of spacing repeating itself has been observed (not shown in Fig. 1). Under low magnification these grouped steps give an appearance resembling optical band spectra.

On another crystal a similar grouping of *five* steps has been observed. In addition, on one face of a crystal the number of steps grouped together has been observed to change in certain regions.

These features can be explained thus. The different polytypes of carborundum have the Ramsdell's zig-zag sequence[2] or Zhdanov[3] symbol of $[(33)_n32]$. Using Frank's notation[4], the structure can be written as $[(\nabla\nabla\nabla\Delta\Delta\Delta)_n\nabla\nabla\nabla\Delta\Delta]$. Whichever orientation has the slowest velocity of growth in any one orientation—say, the first ∇ after a series of Δ's—then it will repeat itself after six such layers, making the growth steps 15 A. high, until we reach the last layer $\nabla\nabla\nabla\Delta\Delta$, which will be only 12·5 A. high. After this the whole sequence will go on repeating itself. Thus, depending upon the number n, we will have a certain number of steps grouping themselves together. The observation of the changing number of grouped steps together suggests a change in type from one part of the crystal to another. This may account for the disagreement between crystal symmetry and X-ray diffraction data sometimes observed[5].

The observation of this grouping of steps is another visual confirmation by crystal growth patterns of the repeat sequence predicted by X-ray phenomena.

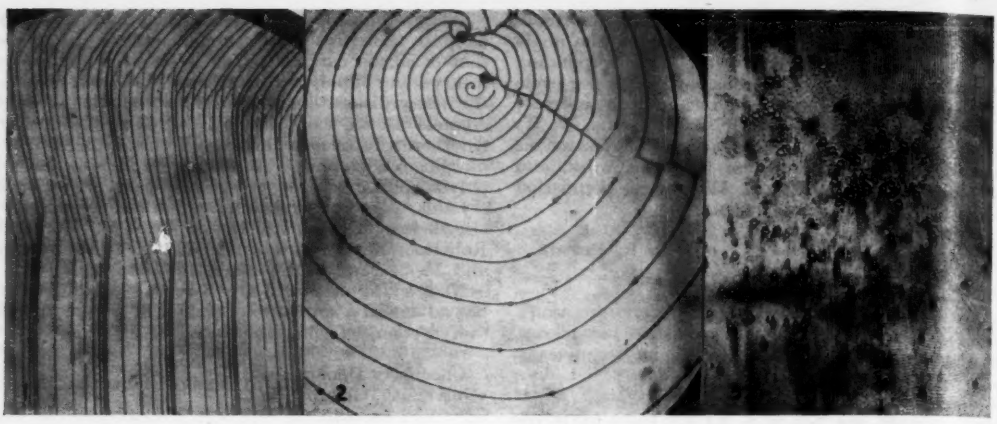

Fig. 2 shows a spiral in which spots are seen just on the edges of the steps. Their size generally increases as we go away from the centre.

Fig. 3 shows a number of hexagonal spirals originating from screw dislocations, the point of emergence of which is marked by a somewhat hexagonal spot. A large number of similar spots with no spirals attached to them are also seen. These are sometimes linearly arranged. At the Bristol Summer School (1951), where some of these pictures were presented, it was suggested by Dr. F. C. Frank that these may be the ends of edge dislocations.

I wish to express my thanks to Prof. S. Tolansky for his interest, and to the British Council for the award of a scholarship.

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Relationship Between the Extinction Coefficient and the Particle Size

The experimental determination of the relationship between the extinction coefficient and the particle size for spherical bodies having diameters less than about 50 microns is of considerable theoretical interest in the verification of certain aspects of the vector theory applicable to the problem, and also of practical importance in the application of the photo-extinction method of powder-size analysis.

For these reasons the relationship has received considerable theoretical and experimental investigation; but, even so, a study of the literature shows that the available data are conflicting.

Further examination of the problem, however, shows that the deviations occurring between the results of the different experimental determinations are probably due to errors arising from the following causes: (1) the suspensions tested are usually composed of ground mineral powders, and so the particles are, in general, not truly spherical; (2) the samples tested are usually sized for diameter by levigation and, owing to the limitations of the method, the size limits are often indefinite; (3) complete elimination of fine material from the sample is difficult, and even traces of residue introduce considerable error; (4) the calculated size characteristics of samples of particles, of size less than say 5 μ, are often unreliable due to errors introduced by Brownian movement and thermal currents in the fluid in which the samples are separated; (5) aggregation of the particles in the suspension occurring during the normal photo-extinction test is undetected, and it is probable that errors of unknown magnitude, arising from this cause, are frequently included.

In the present investigation these sources of error are either eliminated or the magnitude of their effect determined and an appropriate correction applied to the results.

For particles of size up to about 25 μ diameter, spheres of fused powdered glass and of polystyrene are used. The preparation of glass spheres of size greater than about this figure is not practicable so, in order to extend the size-range, a desert sand and a silica sand are used. The particles of these sands approximate closely to spherical, but a small correction for the deviation from sphericity is made upon the basis of the shape factors suggested by Heywood[1].

The glass and sand powders are sized within reasonably close nominal limits of size by repeated levigation, these fractions then being submitted to sedimentation in a photo-extinction apparatus which has been described elsewhere[2], and a curve of $\ln I_0/I$ plotted against the corresponding Stokes's diameter obtained—I_0 and I being the incident and emergent light intensities respectively.

From this curve is calculated the mean size and the size limits of the sample, and also the increment of $\ln I_0/I$ due to the material in this size-range. Furthermore, the approximate weight of the material, mainly of size less than about 2 μ, not removed by levigation, is computed from the curve and an appropriate correction to the concentration of the suspension determined.

The substitution of these corrected values in the equation of light transmission through a suspension of particles,

$$\ln I_0/I = 1{\cdot}5 \frac{C.l}{\rho.d} K_e,$$

allows the calculation of the corresponding extinction coefficient, K_e.

The extinction coefficient for the plastic spheres is determined without recourse to corrections, the diameter as obtained from an electron photomicrograph being used.

It seems probable that by these means the errors enumerated above are almost completely eliminated.

The relationship of extinction coefficient and particle size as obtained from the present experiments is shown by the relevant points on the appended graph, and it will be seen that, in the range where the results for the different materials overlap, the points applicable to desert sand agree well with those for the glass spheres, and those for silica sand agree well with those for desert sand; thus confirming the accuracy of the correction for non-sphericity.

The full line on the graph is considered to be the best line through these points; this line being drawn, for materials less than 10 μ in diameter, to correspond with the theoretical curve suggested by Stratton and Houghton[3], since there is considerable evidence of the validity of the results of these workers for this range, and also the experimental points fall well upon such a curve.

The broken curve shows a portion of the solution suggested by Stratton and Houghton, and for diameters greater than about 17 μ an extension to the solution of Stratton and Houghton suggested, on theoretical grounds, by Brillouin[4].

Within the range 1–2 μ, the experimental data are scanty, but it is interesting to note that two points determined by Vouk[5] fall well upon the curve of Stratton. These points, which do not fall on the curve deduced by Vouk and which appear to have received no mention in his thesis, give further confirmation to the curve of Stratton and Houghton for this range.

From these results it appears that the theoretical extension of the curve of Stratton and Houghton, deduced by Brillouin, is of the form obtained by experiment, and hence that Brillouin's interpretation of the terms in the vector equations is correct.

The agreement between the theoretical and the experimental results also supports the view that the full curve of the graph may be used with confidence in the determination of the size characteristics of fine powders by the photo-extinction method; the procedure for the application of such a curve to this problem has been given in detail elsewhere[6].

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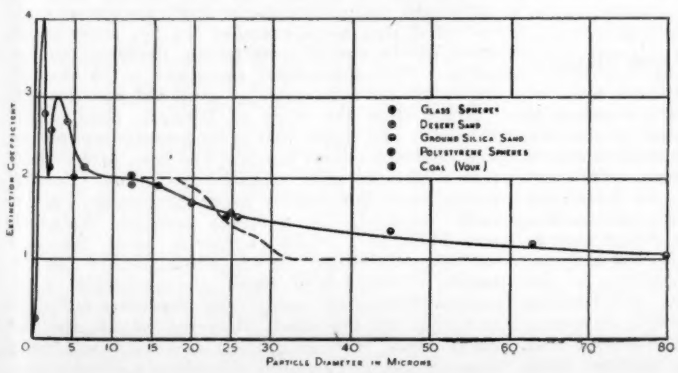

Improving the Performance of a Littrow-type Infra-Red Spectrometer

IN a recent communication in *Nature*, A. Walsh[1] suggested a means of improving the performance of a commercial infra-red spectrometer by adding extra plane mirrors so that the radiation traverses the prism four times instead of twice, and then chopping the partly dispersed radiation so that only the wanted radiation is interrupted and consequently measured. The advantages claimed are that the instrument is in effect converted into a double-monochromator with improved resolution and complete freedom from stray light even at 15 μ.

It is the purpose of the present communication to point out that similar ideas have been suggested previously, and to describe an alternative and perhaps simpler way of applying them to existing spectrometers.

Some years ago, Dr. W. C. Price (then with Messrs. I.C.I., Ltd.) explored the possibility of increasing resolution by traversing the prism four times instead of twice, as indicated in Fig. 1. Resolution is certainly improved, but two difficulties arise: (1) normally the entrance slit is curved to give a straight spectral image on the exit slit, but two extra traversals of the prism will introduce further curvature so that either the exit slit must have curved jaws also or the entrance slit must be given still greater curvature (Walsh does not mention this point in his letter); (2) with so many traversals of the prism, stray light, already troublesome in Littrow-type instruments, is likely to be further increased.

A natural development from Dr. Price's suggestion is to use a small plane mirror close to the entrance slit to reflect the rays back through the prism; but this fails because the initial dispersion is annulled during the third and fourth traversals of the prism. This difficulty is easily overcome by using a pair of plane mirrors at right angles to return the radiation through the prism. (The guiding rule is that radiation in successive traversals must not switch from base to apex of the prism or vice versa.)

We thus arrive at the arrangement proposed by Walsh, but in our modification the plane mirrors are placed above the entrance slit instead of alongside (Fig. 2). This arrangement is generally more easily applied to an existing

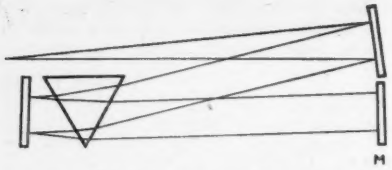

Fig. 1. Littrow system with additional plane mirror *M*, as used by Dr. W. C. Price

spectrometer and has the advantage that the small angle off-axis in a vertical plane (about 1° in the *S*3 spectrometer) tends to reduce the curvature of image already mentioned. In practice, it is unnecessary to make any alteration to the slits, which is a point of some practical importance.

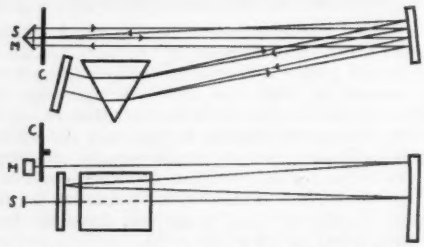

Fig. 2. Plan and elevation illustrating a simple method of converting a single- to a double-monochromator. *S* is the entrance (and exit) slit and *M* a pair of plane mirrors mounted at right angles to each other

The elimination of stray light by chopping after initial dispersion has already been described[2]. In our arrangement the chopper *C* is placed at the position shown in Fig. 2. If the primary spectrum is imagined spread out horizontally across the pair of mirrors, only a small band of wave-lengths will be intercepted by them. If stray light of some other wave-length happens also to fall on these mirrors, it will, of course, be interrupted, but will be separated from the wanted radiation during the further traversals of the prism.

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The Xi-Phase and a New Sigma Phase

Six phases with structures isomorphous with the iron–chromium sigma phase have been reported in binary alloys of the transition elements of the first long period[1–3]. In addition, Goldschmidt[4] has shown that the phase FeMo, stable between 1,180° and 1,540° C., has the same structure. In the binary system cobalt–molybdenum, a similar phase Co_2Mo_3 exists between 1,250° and 1,620° C.[5]; recent work in this Laboratory has shown that Co_2Mo_3 has a sigma-phase structure. The interplanar spacings of the alloy containing 61 atomic per cent molybdenum are very similar to those of the alloy with 50 atomic per cent FeMo given by Goldschmidt, except that they are slightly smaller, as might be expected when the slightly smaller cobalt atom replaces iron. Multiplying the Co_2Mo_3 *d*-values by 0·981 gives values which agree well with those for FeCr given by Goldschmidt[4].

As in the iron–molybdenum system, the cobalt–molybdenum sigma-phase has only a limited temperature-range and decomposes peritectoidally to form the xi-phase Co_7Mo_6, which has a rhombohedral structure stable over a wide range of temperature. It is of interest to compare the occurrence of the sigma- and xi-phase in the binary systems of iron and cobalt with chromium, molybdenum and tungsten respectively. Where the second element is in the same period the only intermediate phase is sigma, which has a wide stability range. With molybdenum, both iron and cobalt form a sigma-phase, though this has only a restricted stability-range and decomposes to the xi-phase. In the case of tungsten, the xi-phase only is found. The reason for this transition does not appear to be predominantly a size effect, as there is little difference in the atom sizes of molybdenum and tungsten; it is more probable that it is an electronic one. The xi-phase may thus also be an electron compound, as has been suggested by Sully[6] for the sigma-phase; as is the case with the sigma-phase, the proportions of molybdenum and tungsten are greater in the cobalt phases than in the iron ones.

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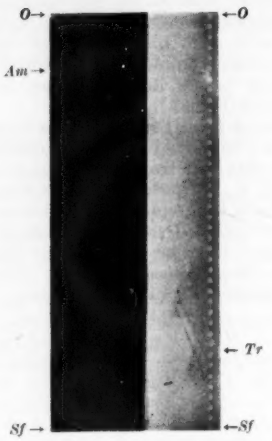
Separation of Enzymes by Paper Chromatography

In a recent publication[1] from this laboratory, a technique for the study of the chromatographic behaviour of enzymes on paper was described. The ease with which enzymes can be readily identified on the paper chromatogram by the agar-plate method enabled us to study the chromatographic behaviour of some of the important enzymes. In the course of preliminary experiments with amylases, phosphorylases and phosphatases from various sources, we found that some enzymes did not move at all while others moved considerable distances on the paper. This observation prompted us to attempt the separation of enzymes by paper chromatography.

Apart from the work of Mitchell, Gordon and Haskins[2], who report that some separation of adenosine deaminase from amylase has been achieved by their 'chromatopile' method, no really complete separation of enzymes by paper chromatography has been reported. In a recent note by Wallenfels and Pechman[3], which appeared after we sent our communication[1] on the technique for the detection of enzymes on paper, the separation of the enzymes of a mould extract by a micro-electrophoretic technique was described. However, by adopting the usual paper chromatographic technique and using aqueous acetone or sodium chloride or a suitable com-



Chromatogram showing the separation of amylase from trypsin: *O*, origin; *Sf*, solvent front; *Am*, amylase; *Tr*, trypsin

bination of these two as developing solvents, we have been successful in achieving a few good separations of the individual enzymes from mixtures prepared artificially or obtained from natural sources such as mould or tissue extracts.

As a typical example of the separation that can be so readily obtained by the paper chromatographic method, we reproduce a photograph of the separation of amylase from the proteinase, trypsin, present in commercial trypsin powder (Pfanstiehl Chemical Company). From the photograph, it can be seen that the amylase shows little or no tendency to move, whereas trypsin has moved quite a distance from the starting line, and a complete separation of the two enzymes is thus obtained. As it is necessary to adhere to our procedure to be able to reproduce successfully the above separation, we are giving below the essential features of our method.

A 2 per cent aqueous solution of commercial trypsin powder was prepared and centrifuged to remove the suspended impurities. By means of a micro-pipette (11 μl.) two spots of the enzyme solution were placed, at an interval of 4 cm., on the starting line of the filter paper strip (Whatman No. 1, 40 × 8 cm.). The chromatogram was run at low temperature (0–5° C.), the developing solvent being 50 per cent aqueous acetone containing 1·5 per cent sodium chloride. After the solvent front had advanced a distance of 25 cm. from the starting line, the filter paper strip was removed from the chromatographic chamber and cut into two strips (*A* and *B*) longitudinally, to locate the positions of the two enzymes. The position of the amylase on strip *A* was detected by the method previously described[1]. The elegant and simple method of Wallenfels and Pechman[3] for the detection of proteinases was used for locating the trypsin on the chromatogram. Accordingly, strip *B* was placed on the wetted gelatin side of a 35-mm. ciné-film strip about 12 in. long. The combination was placed in an incubator at 30° C. and water was sprayed, at intervals, on to the paper to keep it moist. After about two hours, which was sufficient for the trypsin to liquefy the gelatin, the paper was removed from the film strip. The position of the enzyme, trypsin, on the paper is indicated by liquefaction of the gelatin, resulting in the formation of a clear zone.

It is interesting to note that neither aqueous acetone nor water alone is able to bring about any appreciable movement of trypsin. However, the addition of sodium chloride in concentrations as little as 0·5 per cent to the aqueous acetone or water results in the trypsin moving a considerable distance from the starting line. Further, we have observed that the use of saline solutions enhances the definition of the spots by arresting tailing.

Details of the other separations of enzymes so far achieved by us will be published elsewhere.

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Dissociation of Complex Ions in Non-Aqueous Solvents

We have developed recently[1] a method for the micro colorimetric estimation of iron as triphenylmethylarsonium hexathiocyanato ferrate III, $(Ph_3MeAs)_3(Fe(CNS)_6)$, in which this compound was extracted from aqueous solution with *o*-dichlorbenzene in the presence of about seventy equivalents of triphenylmethylarsonium thiocyanate. The orange-red solution had a sharp absorption maximum at 478 mμ (curve *A*), the same wave-length as that observed by Woods and Mellon[2] for the ammonium salt $(NH_4)_3(Fe(CNS)_6)$ in water.

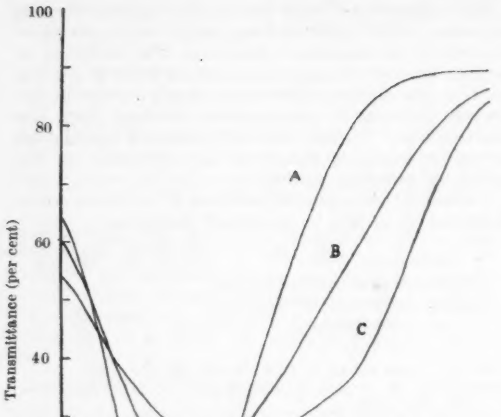
The solid, analytically pure, iron compound could be isolated as a dark red crystalline powder. In *o*-dichlorbenzene this gave a purplish-red solution, with a broad absorption maximum at 488 mμ (curve *B*). The solution became violet when warmed, and reddish when cooled in ice. When the solution was progressively diluted with the solvent and correspondingly thicker cells were used for the determination of the absorption curve, the colour also became violet, developing a sharper absorption maximum at 520 mμ, while in the most dilute solutions a new absorption maximum commenced to develop in the region of 600 mμ (curve *C*). Addition of triphenylmethylarsonium thiocyanate to the violet solutions changed the colour to orange-red. The colour changes are not due to colloidal micelles of different sizes, since a large excess of triphenylmethylarsonium perchlorate caused the violet solutions to become only slightly redder.

The various arsonium compounds used were soluble in a wide variety of non-aqueous solvents such as chloroform and ethylene dichloride in spite of the fact that they are salts. This is undoubtedly due to the large covalent moiety and the existence of ion pairs in the solution.

The colour changes are consistent with the following equilibria, in which arsonium thiocyanate is detached from the complex salt as an ion pair:

$$(Ph_3MeAs)_3(Fe(CNS)_6) \rightleftharpoons (Ph_3MeAs)CNS + (Ph_3MeAs)_2(Fe(CNS)_5) \rightleftharpoons 2(Ph_3MeAs)CNS + (Ph_3MeAs)(Fe(CNS)_4).$$

The triphenylmethylarsonium radical confers solubility in organic solvents on a great number of com-



Curve *A*: $(Ph_3MeAs)_2(Fe(CNS)_4)$ in *o*-dichlorbenzene (4·0 μgm. Fe/ml.) + 70 equivalents of $Ph_3MeAsCNS$. 0·5 cm. cell.
Curve *B*: $(Ph_3MeAs)_2(Fe(CNS)_4)$ in *o*-dichlorbenzene (4·0 μgm. Fe/ml.). 0·5 cm. cell.
Curve *C*: $(Ph_3MeAs)_2(Fe(CNS)_4)$ in *o*-dichlorbenzene (0·5 μgm. Fe/ml.). 4·0 cm. cell.

plex anions such as $FeCl_4'$, BiI_4', $Co(CNS)_4''$, and dissociation of the above type is probably a general phenomenon.

The dissociation of complex salts in water, as pointed out by Bjerrum[3], is complicated by the competition of water molecules for co-ordination positions of the metal, so that complexity constants are not measures of the affinity of the metal for a particular ligand, but of the change in free energy when a solvent molecule is replaced by the ligand. The determination of dissociation constants in solvents such as *o*-dichlorbenzene or carbon tetrachloride should give a very close evaluation of the true affinities of metals and ligands, as well as the energy of dissociation, since these solvent molecules can be attached by only the weakest of bonds.

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Identity of Lespedin with Kæmpferitrin

From the leaves of *Lespedeza cyrtobotrya* Miquel, a deciduous shrub of the natural family Leguminosæ, M. Hasegawa and I isolated a kæmpferol glycoside which we named lespedin[1,2], its structure being shown to be kæmpferol 3,7-dirhamnoside. It has also been isolated from *Celastrus orbiculatus* Thunberg (family Celastraceæ) by M. Kanao and M. Shimokoriyama[3].

When crystallized from water, lespedin had melting point 195° with or without water of crystallization ($3\frac{1}{2}H_2O$), whereas from ethanol it melted at 234°. It thus appeared to be different from kæmpferitrin, melting point 201–203° [4].

Having learnt from Dr. E. C. Bate-Smith that the kæmpferitrin employed in his chromatographic studies was obtained from the original collection of the late Prof. A. G. Perkin (through the courtesy of Dr. E. J. Cross of the Department of Colour Chemistry, University of Leeds), I sent a specimen of lespedin to Dr. Bate-Smith in order to have the mixed melting point of the two glycosides tested. The results he has communicated to me are as follows:

	Softening point	Melting point
Kæmpferitrin	190–192°	194°
Mixture	190–194°	195°
Lespedin	190–194°	195°

*R*F values in butanol – acetic acid – water (4 : 1 : 5) and phenol – water are for both 0·71. The colours given in ultra-violet light and in ammonia are also identical.

I am satisfied that the identity of lespedin with kæmpferitrin has been thus established, and the name 'lespedin' becomes, therefore, redundant.

I wish to thank Dr. T. Swain, who carried out the determinations, and Dr. E. C. Bate-Smith, both of the Low Temperature Research Station, Cambridge, for their kindness.

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Cholinesterase Activity in the Secretions of the Pancreas of the Dog and Parotid of the Pig

It has been recognized for some time that the pancreas of the dog contains large amounts of pseudo-cholinesterase[1], and the parotid gland of the pig is known to have a much higher cholinesterase activity than other digestive glands in this species[2]. Ginsberg *et al.*[3], using a biological method, found that dog's pancreatic juice possessed at least fifteen times the enzyme activity of the blood, but this observation does not so far seem to have been confirmed.

In view of this work and other experiments which will be reported separately, dog's pancreatic juice, secreted in response to different stimuli, was examined for the presence of pseudo-cholinesterase. The animals were anæsthetized with chloralose before cannulation of the accessory pancreatic duct. Extracts of the mucosa of the small intestine and pilocarpine were injected intravenously to stimulate secretion. Pseudo-cholinesterase in the juice and in water homogenates of the gland was estimated manometrically at *p*H 7·4 with 0·06 *M* acetylcholine perchlorate (B.D.H.) as the substrate. The unit of cholinesterase is defined as the amount of enzyme which liberated 1 μl. carbon dioxide/min.

PSEUDO-CHOLINESTERASE ACTIVITY OF DOG'S PANCREATIC JUICE AND PANCREAS

Exp.	Pancreatic juice secreted in response to: Pilocarpine (units/ml.)	Secretin preparation (units/ml.)	Vagal stimulation during secretin flow (units/ml.)	Pancreas (units/gm.)
I	3,240	420	—	1,450
	3,120	500		
II	1,380	1,080	1250	2,000
	1,450			
III	2,700	765	1470	2,570
	2,870	960	1870	

The activity of the pseudo-cholinesterase in the pancreatic secretion of three dogs is shown in the accompanying table.

The results indicate that pseudo-cholinesterase can be present in high concentration in the pancreatic juice of the dog, and in these experiments the amounts appeared to vary according to the stimulus employed, in a manner similar to that of the other enzymes of the juice. In two of the experiments the activity of the secretion was greater than that of the gland, which was removed at the end of the experiment.

Parotid saliva was obtained from two pigs anæsthetized with chloralose, and from two after decerebration under ethyl chloride and ether anæsthesia. Difficulty was experienced in estimating the cholinesterase activity in a satisfactory manner; but it was clear that acetylcholine was hydrolysed at a high rate by the parotid saliva (saliva 30–640 units/ml.; gland 410–670 units/gm.; serum 10 units/ml.).

These preliminary experiments confirm that cholinesterases may be secreted actively by glands[4]. It is not yet possible to assess the significance of their presence in the secretions of digestive glands; but they may have some useful function in the lumen of the gut.

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Stimulation of Bile Secretion in Chick Embryos by Cortisone

IN some preliminary experiments it was observed that the administration of cortisone to twelve-day old chick embryos caused their gall bladders to become distended and bile to flow prematurely into their intestines. Accordingly a substantial experiment was performed to confirm or deny these preliminary findings, and since there are certain difficulties associated with obtaining either rapid or complete absorption of substances injected into chick embryos, comparatively large doses of cortisone were employed. A dose of 5 mgm. of cortisone ('Cortone acetate') was given to each of sixty White Leghorn chick embryos on the twelfth day of incubation, either by injecting it into the yolk or on to the chorioallantoic membrane. For controls, seventy-five embryos were similarly injected with the same volume of normal saline. The eggs were harvested on the fifteenth day of incubation. The diameters and the lengths of the gall bladders were measured with calipers and their volumes were determined by assuming them to be cylinders. Observations were made in each instance on whether or not bile had reached the intestine to colour it green.

Forty of the sixty embryos receiving cortisone had larger gall bladders than the largest encountered in the control series. The average calculated volume of gall bladders in the cortisone group was 21·1 c.mm. and that of those in the control series 6·9 c.mm. In twenty-eight of the cortisone-treated embryos, bile had reached the intestine to colour it green; this had not occurred in any of the control embryos.

The finding that cortisone can stimulate bile secretion raises the interesting question of how this effect is exerted. With regard to the possibility of the injected cortisone contributing to the formation of bile salts, which in turn produce the effect observed, it should be noted that in our experience the injection of sodium dehydrocholate into twelve-day old chick embryos also stimulates bile secretion; hence the liver at this stage of development is competent to respond to a bile salt stimulus. But since Paschkis, Cantarow, Walkling, Pearlman, Rakoff and Boyle[1] have shown that carbohydrate-active oxysteroids can be recovered from the bile of dogs given adrenal cortical extracts, the possibility of cortisone being excreted as such into bile and, in being excreted, directly stimulating the flow of the medium in which it is contained, should also be considered.

We wish to acknowledge financial assistance from the National Cancer Institute of Canada and the Foster Bequest Fund of the University of Toronto.

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Antivitamin D Factor

RICKETS, attended by a reduction in gain of weight, has been frequently reported in weaned lambs grazing on green oat plants and other green feeds during the winter in the South Island of New Zealand[1,2]. The effect is not confined to green feeds grown in this country, since Ewer has demonstrated a rachitogenic effect of green oats grown in England[3].

Previous work in New Zealand[2,4,5] has shown that there is adequate calcium and phosphorus in the rickets-producing plants and that supplementary feeding of calcium and/or phosphorus does not prevent the disease. Rickets was prevented and normal growth-rate restored by a single massive dose of 'Calciferol' (1,000,000 i.u.) given at the commencement of green feed grazing[5], but not by weekly doses of cod liver oil which provided an average of 300 i.u. of vitamin D a day, which is approximately twice the normal daily requirement of young sheep[6]. It was therefore postulated that a rachitogenic factor was present in the green feeds on which ovine rickets

occurs. Further support for this hypothesis has been obtained from a recent investigation[7] which suggested that the incidence of solar ultra-violet radiation on sheep grazing green oats was at least as great in an area where rickets occurred as in one where no rickets developed.

A laboratory study was undertaken at this Research Station to investigate the nature and occurrence of the rachitogenic factor in green oats. The white rat was employed as the test animal, and it was kept under the same regime as that developed by Hume *et al.*[8] for the biological assay of vitamin D. By measuring the influence of oat extracts on the ash content of rat bones, the existence of an anti-vitamin D factor has been firmly established. Some of the results are outlined in the accompanying tables.

Table 1 indicates the rachitogenic properties of a chloroform-extract of dried young green oats when given to rats in dilute solution in olive oil. The results summarized in Table 2 indicate the pronounced effect of the oat extract in depressing the bone ash response to vitamin D.

Table 1 (12 rats per group)

Group	Daily dose	Average % ash in dry fat-free femur
1	0·3 gm. olive oil	31·2
2	0·3 gm. solution *X**	27·8

* *X* is a 1 in 30 dilution of the oat extract in olive oil.

Table 2. (7 rats per group)

Group	Daily dose	Average % ash in dry fat-free femur
1	0·3 gm. olive oil containing 0·1 i.u. vitamin D	34·6
2	0·3 gm. solution *X* containing 0·1 i.u. vitamin D	30·1
3	0·3 gm. olive oil containing 0·2 i.u. vitamin D	38·3
4	0·3 gm. solution *X* containing 0·2 i.u. vitamin D	33·1
5	0·3 gm. olive oil containing 0·3 i.u. vitamin D	40·9
6	0·3 gm. solution *X* containing 0·3 i.u. vitamin D	37·0
7	0·3 gm. solution *X* containing 0·4 i.u. vitamin D	38·2

That these results were not due to any factor associated with the oat extract which might reduce the amount of vitamin D absorbed from the gut was demonstrated in another experiment by administering the vitamin subcutaneously and solution *X* orally (Table 3). In each of the four weeks of the trial period, each rat received a subcutaneous dose of 0·1 gm. olive oil containing 2·0 i.u. vitamin D.

Table 3. (7 rats per group)

Group	Daily dose *per os*	Average % ash in dry fat-free femur
1	0·3 gm. olive oil	34·2
2	0·3 gm. solution *X*	27·3

Similar results have been obtained with extracts of young Italian ryegrass, a feed on which winter-grazed hoggets often develop the disease.

Some preliminary work on permanent pasture, on which feed the development of ovine rickets has not so far been reported, has demonstrated that it contains both vitamin D and the antivitamin D factor. Rats on the standard rachitogenic ration developed more severe rickets when dosed with an extract of the young green leaves; but the opposite effect—an increase in the degree of bone calcification—resulted from dosing with an extract of the brown dead leaves. Such dead matter often makes up a considerable proportion of a sample of well-established pasture. The net result of the two effects observed when an extract of the whole pasture sample was given to rats was an increase in bone calcification. That this extract also contained the antivitamin D factor was demonstrated by the fact that a measured amount of vitamin D added to it did not increase the extent of bone calcification by the expected amount. Whether both vitamin D and the antivitamin D factor exist together in varying proportions in both the green and dead material has yet to be determined.

Further studies on the distribution and physiological action of the antivitamin D factor are being made, and work is progressing towards its isolation.

From this investigation, it is apparent that for many materials of plant origin the biologically determined assay figures for vitamin D should be accepted with some reserve, until the physiological action and distribution of the antivitamin D factor has been more fully investigated.

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A Further Example of *Kidd* (*Jk*^{a}) Hæmagglutinin

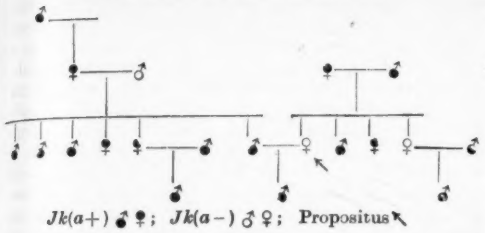
Recently Allen, Diamond and Niedziela[1] reported a previously unidentified blood-group antibody which they termed anti-*Kidd*, or anti-*Jk*^{a}. Samples of the serum were most generously sent us by Dr. Allen and Dr. R. R. Race. With these we have identified an antibody of apparently identical specificity.

This antibody was found in the serum of a woman, Mrs. McGimpsey (*McGi*), who is *Rh*-negative, and whose blood was being examined for antibodies as a routine measure during her first pregnancy. She has never had a transfusion. She gave birth to a normal boy on May 17, 1951. On May 29 a direct Coombs test on his blood was negative.

A sample of Mrs. McGimpsey's serum, drawn on February 14 and tested by both the capillary method for saline antibodies and the test-tube for albumen antibodies, did not agglutinate either of two test cells, one being *O, MS, CDe.cDE, Kk, Lu(a−), Jk(a+)*; the other, *O, Ms, Cʷ De.CDe, kk, Lu(a−), Jk(a+)*. A specimen drawn on April 26 agglutinated both test cells in saline in the capillary, with a doubtful reaction in albumen in the test-tube. It agglutinated eight other *Kidd*-positive cells and did not agglutinate 8 *Kidd*-negatives. This appears adequate proof of its specificity.

The inheritance of the factor defined by the serum *McGi* was investigated in some of the members of the family, as set out in the diagram. Identical reactions were given by anti-*Kidd* and anti-*McGi*.

Inheritance of Jk^a in Family *McGi*



$Jk(a+)$ ♂ ♀; $Jk(a-)$ ♂ ♀; Propositus ↖

Of 146 pregnancy and premarital bloods of groups *O* and *A*, 77·4 per cent (113) were agglutinated by *McGi*. Allen *et al.*[1] reported the antigen Jk^a to be "present in the red cells of about 77 per cent of Americans".

Our serum reacts both at room temperature and at 37° C., but better at the latter, by both the capillary method and the test-tube method for saline antibodies.

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Temperature Characteristics of the Microflora of Central African Soils

The importance of a knowledge of the effect of temperature on the metabolic activities of the soil microflora can scarcely be questioned, especially in the case of tropical soils. Furthermore, the temperature characteristic of the metabolic activities calculated by the Arrhenius's law :

$$V = \exp(-\mu/RT),$$

where V is the rate of the process, R the gas constant and T the absolute temperature, may be considered as the activation energy of the slowest or 'pacemaking' process in the chain of enzymatic mechanisms[1]. In this case it would be possible to use this method as a kinetic analysis of the slowest enzymatic processes in the metabolism of the soil microflora.

The experimental results presented here report our preliminary findings regarding the order of magnitude of the activation energy calculated from the rate of oxygen uptake at different temperatures. The measurements of oxygen uptake were always made on soils immediately after they had been brought to the laboratory, that is, less than three hours after sampling. Sampling was carried out with a cylindrical soil auger to the depth of 10 cm. About twenty samples were mixed in the field and the composite sample was brought to the laboratory.

The rate of oxygen uptake at temperatures between 28° and 38° was determined on 50-gm. portions of soil (passing a 4-mm. sieve and retained by 1-mm.) with the differential manometer as modified by Lees[2]. Triplicate determinations were made for each temperature. The rate of oxygen uptake of soils recently taken from the field was reasonably constant during the first 30 hr. We have used this value as a measure of the metabolic activity of soil microflora.

Temperature Characteristics and Rate of Oxygen Uptake of Central African Soils

Soil No.	Oxygen uptake (μl. per hr. per gm. of soil at 28° C.)	Temperature characteristic (μ) cal.
1	5·0	7,500
2	4·0	10,000
3	3·2	7,500
4	2·7	7,000
5	1·1	16,000
6	0·6	16,000

(1) Forest soil under *Cynometra alexandri* Harms ; (2) old rubber plantation ; (3) forest soil from glade, under second growth ; (4) old pasture of *Panicum maximum* and *Digitaria* (soil 1 to 4 on Yangambi reddish-yellow latosol) ; (5) colluvial sandy soil under young (5–7 years) second-growth forest ; (6) the same, four months after felling and burning forest.

The accompanying table presents the observed values for the rate of oxygen uptake at 28° C. and temperature characteristics calculated from the rates at temperatures between 28° and 38° C. The order of magnitude of the values determined for these temperature characteristics agrees well with those given by Crozier for various biological reactions.

It will also be observed that μ values for soil microflora are quite close to the corresponding figures in biological reactions, namely, 16,000, 11,000 and 8,000 cal.

It may be of interest to note that the very sandy soils studied here showed constantly a higher value of μ than the less sandy soils in the same region. Together with other factors, a more pronounced influence of temperature on the microflora of sandy soils might explain the greater difficulty in maintaining the soil organic matter content in light-textured tropical soils.

Work is now in progress on the analysis of the 'pacemaking' process in the metabolic activities of the soil microflora through selective poisoning of characteristic enzymatic systems.

H. Laudelout
J. Meyer

Division d'Agrologie,
Institut National pour l'Étude
Agronomique du Congo Belge,
Yangambi, Belgian Congo.
June 15.

[1] Crozier, W. J., *J. Gen. Physiol.*, **123**, 136 (1924).
[2] Lees, H., *Plant and Soil*, **2**, 123 (1949).

Acid Tolerance in Plants

The failure of certain plant species to thrive on acid soils has been ascribed to an intolerance of the acid conditions.

A number of tree species, such as ash and *Pinus halepensis*, which are usually associated in Nature with alkaline soils, have been the subject of experiments designed to throw light on this supposition. In one such experiment, carried out in pot cultures and in the field, seeds of these trees were sown in the acid soil of Wareham Heath and in this same soil to which compost had been added. The Wareham soil had a *p*H value of 4–4·5 ; the compost used had an acid reaction, and the *p*H value of the soil remained virtually unaltered after addition of the compost. The resulting growth in the untreated Wareham soil was extremely poor, whereas in the composted soil it was excellent, notwithstanding that the reaction of the rooting medium was but little more than *p*H 4.

The behaviour of a number of agricultural crop plants was also studied, for example, red clover,

Red clover (*Trifolium pratense*) 9 weeks from sowing: (1) soil reaction, *p*H 7; (2) soil reaction, *p*H 4

alsike clover, buckwheat, lucerne, wheat. All these showed good growth under compost treatment in the soil of low *p*H value, quite comparable with that in a compost-treated neutral soil (see accompanying illustration).

From such results it would appear that the limiting factor for growth is not the low *p*H of the soil, since the inhibition to growth can be removed with negligible change in the soil reaction. Addition of a suitable compost is only one way of bringing this about; modification of the soil environment in other ways not involving raising the *p*H may be equally effective when they can be employed, among them establishment of a mycorrhizal relationship previously lacking.

W. Neilson Jones
Ida Levisohn

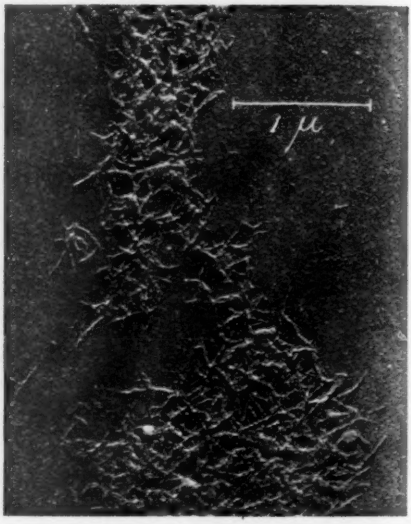
Bedford College,
University of London.
Sept. 27.

Formation of Silk Fibre by the Silkworm

The silk-producing apparatus of the common silkworm provides a convenient system for the study of several aspects of the synthesis of fibrous proteins. It is particularly useful for the investigation of the transformation from the soluble precursor protein of the gland into the solid, insoluble, fibrous fibroin. The precursor, which may be called 'fibroinogen', accumulates in solution in the silk gland and is converted into the fibre by the disturbances produced during spinning. Certain structural problems have recently been studied by Kratky, Schauenstein and Sekora[1,2], who have described an X-ray pattern characteristic of the soluble precursor, which appears to differ from the well-known pattern of silk fibre. Similar observations have been made by us.

The fibroinogen can be extracted from the silk gland by water and forms at first a slightly turbid solution, which exhibits the usual reactions of soluble proteins[3]. On standing for a few hours, the turbidity increases and the protein separates as a fibrous precipitate. X-ray patterns of the precipitate were found to be similar to those of the ground-up silk fibre (silk 2 according to Kratky *et al.*[1]) and distinct from the carefully dried gland (silk 1)[1]. It appears, then, that the change into the fibrous form can proceed spontaneously in dilute solution without the participation of mechanical stress.

The formation of the fibrous precipitate has been further studied by means of electron microscopy. Examination of the freshly prepared extract dried on collodion films revealed no significant structure, but the aged solution yielded fields, such as that shown in the accompanying electron-micrograph, in which the predominant component is a fine fibril about 100 A. in diameter and up to 3,500 A. in length. The soluble precursor of fibroin thus exhibits the property, already made familiar by electron microscopical studies of fibrin[4] and actin[5,6], of forming fibrils spontaneously in solution.



Since silk fibre is not usually thought to be an aggregation of fine fibrils, a further electron microscopic study was made of fibre spun in the normal way. Natural silk was disintegrated by prolonged tryptic digestion and the fine fibrillar fragments examined electron microscopically. These fragments were found to consist of fine fibrils of a similar diameter to, but greater length than, those shown in the electron-micrograph, and aligned parallel to the length of the fibre, demonstrating that, in the fibre spun in the normal way, there occurs a morphological feature intermediate in size between the molecular level and the whole fibre. Zahn[7] has reported similar observations, and the large spacings found by means of X-rays[8] also point to the existence of large structural elements.

The formation of silk fibre by the extrusion of the viscous contents of the gland or by the stretching of the gland appears closely analogous to the process of making artificial fibres, and suggests that the polypeptide chains of the soluble corpuscular molecule unfold and from this state are drawn into parallel strands by stretching[8]. On the other hand, the spontaneous appearance of fibrils in solution seems more simply explained as being due to an unsym-

metrical aggregation of the particles of the soluble form without the occurrence of unfolding. There is evidence that this is the case with actin and fibrin. This theory, which may be referred to as 'the linear aggregation theory', could also account for the existence of discrete fibrils and the large lateral spacings.

Since the formation of an unsymmetrical aggregate may prove the characteristic step in fibre building, the conditions of its formation and other aspects of the theory are being investigated. The initiation of such aggregation may rest with purely colloidal forces, as will be shown in future publications from this laboratory. Afterwards, in the linear aggregate, short-range forces could ensure the orientation of the component molecules (or complexes) and thus lead to a fibril oriented at the molecular level, as is required to account for the fibre-type X-ray pattern. The mechanical stresses set up during spinning probably merely orient the preformed fibrils. Further research is necessary to elucidate the nature of the modification in small-scale molecular structure which also seems to accompany fibril formation.

E. H. Mercer

Chemical Physics Section,
Division of Industrial Chemistry,
Commonwealth Scientific and
Industrial Research Organization,
Melbourne.
July 11.

[1] Kratky, Schauenstein and Sekora, *Nature*, **165**, 319 (1950).
[2] Kratky, Schauenstein and Sekora, *Nature*, **165**, 527 (1950).
[3] Foa, *Koll. Z.*, **10**, 7 (1912).
[4] Hawn and Porter, *J. Exp. Med.*, **86**, 285 (1947).
[5] Jakus and Hall, *J. Biol. Chem.*, **167**, 705 (1947).
[6] Rozsa, Szent-Györgyi and Wyckoff, *Biochem. et Biophys. Acta*, **3**, 561 (1949).
[7] Zahn, *Koll. Z.*, **112**, 91 (1949).
[8] Meyer, "Natural and Synthetic High Polymers", 453 (Interscience Pub., 1942).

Effect of Hosts on the Egg Coloration of the Parasite *Bracon gelechiæ* Ashmead (Braconidæ)

Salt[1] has reviewed the literature on the effect of hosts upon their insect parasites. Knight[2] found that a carotinoid pigment of the bug *Perillus* was obtained from its prey, the potato beetle (*Leptinotarsa decemlineata*). Toumanoff[3] discovered that in *Dixippus morosus* the pigmentation may be transmitted by the female to the eggs and so to the offspring. I have not come across any record of the effect of hosts upon the pigmentation of the eggs of the parasite.

Bracon (*Microbracon*) *gelechiæ* Ashm. is an ectoparasite of the larva of the potato tuber moth, *Gnorimoschema operculella* Zell. In my laboratory experiments I found the Braconid to be polyphagous, parasitizing caterpillars of various moths, for example, the Pyralids *Scirpophaga nivella* F., *Argyria sticticraspis* Hamp. and *Chilo zonellus* S., and the Noctuids *Plusia orichalcea* F., *Sesamia inferens* W. and *Earias insulana* B. The parasite was reared on the caterpillars of each of these hosts up to the fifth generation. Except in the eggs of the parasite reared on *P. orichalcea* and *E. insulana*, no marked change in the pigmentation of the egg of the parasite was observed. The eggs laid by the females of the second generation reared on the above two species showed a slight tinge of yellow pigmentation; the pigmentation of the eggs produced by the females of each subsequent generation gradually increases, and ultimately the eggs produced by the females of the fifth generation thus reared are distinctly yellow in colour. This coloration is more intense in the eggs of the females of the fifth generation reared on *Earias insulana*. It is interesting to note that the coloration of the cocoons of the parasites of the fifth generation is yellow. It is worth mention also that when the adult Braconids thus obtained from coloured eggs are again reared on the natural host, *G. operculella*, it is found that the yellow pigmentation is markedly present in the eggs laid by the females of the next generation; but the yellow pigmentation of the eggs laid by the females of each of the subsequent generation decreases in stages. Up to the fourth generation the pigmentation, though insignificant, still persists, and is at last lost in the eggs laid by the females of the fifth generation. The normal white colour of the eggs is thus restored.

In the present case, therefore, the coloration of the eggs of the parasite is clearly a character which is induced by the host, through an article of food, and hence an important factor is environment.

G. C. Sen Gupta

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India.
May 28.

[1] Salt, G., *Biol. Rev.*, **16**, 239 (1941).
[2] Knight, H., *Ann. Ent. Soc. Amer.*, **17**, 288 (1924).
[3] Toumanoff, K., *C.R. Soc. Biol., Paris*, **98**, 198 (1928).

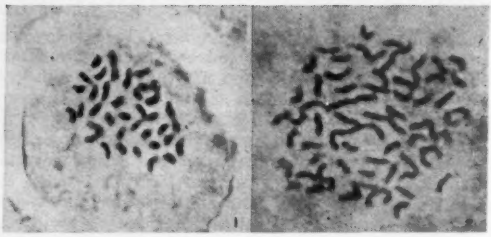
Chromosome Numbers of *Cerastium* Species

Since my publication of chromosome counts of *Cerastium* species in 1950[1], five further counts have been made, two of British material, *C. arvense* L. and *C. viscosum* L., and three of Continental material, *C. dichotomum* L., *C. tomentosum* L., and *C. alpinum* L. The results for these species are shown in the accompanying table.

Species	$2n$	Original source of material
C. arvense L.	72	Isle of Man
C. viscosum L.	72	Malham Tarn, Yorkshire
C. dichotomum L.	38	Not known. Seed obtained from Botanika, Zahrada University, Karlovy, Prague
C. tomentosum L.	72	Not known. Cultivated garden plant
C. alpinum L.	*c.* 144	Abisko, Sweden

The counts for the British material, *C. viscosum* L. and *C. arvense* L., both $2n = 72$, agree with counts made by Rohweder[2], who used Continental material, though I have also counted $2n = 38$ for *C. arvense* L. collected in the Alps[1].

Of the Continental material, *C. dichotomum* L., $2n = 38$ (Fig. 1), has not previously been counted. *C. tomentosum* L., $2n = 72$ (Fig. 2), has also been counted by Rohweder[2], who, however, obtained $2n = 38$. It would appear that this species, like *C. arvense* L., is a complex one containing plants with at least two different chromosome numbers, namely, $2n = 38$ and $2n = 72$. It is hoped that crossing experiments will help to elucidate these two species.



Somatic metaphase plate of (1) *C. dichotomum* L., showing 38 chromosomes; (2) *C. tomentosum* L., showing 72 chromosomes. × 1,500

The count of $2n = 144$ for *C. alpinum* L. is only an approximation, as an accurate count has not yet been possible. The number certainly exceeded $2n = 108$ and $2n = 72$, which I[1], and other workers[3–5], have previously recorded for *C. alpinum* L. It would appear that this species contains a polyploid series, $2n = 72$, $2n = 108$, $2n = 144$.

Olive E. Brett

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University of London, E.1.
June 23.

[1] Brett, O. E., *Nature*, **166**, 446 (1950).
[2] Rohweder, H., *Beih. Bot. Centralblatt*, **59**B (1939).
[3] Böcher, T. W., *Svensk. Bot. Tid.*, **32** (1938).
[4] Löve, A., and Löve, D., *Arkiv för Bot.*, **31** (1944).
[5] Löve, A., and Löve, D., Dept. Agric. Rep., Reykjavik, Series B, No. 3 (1948).

Statistical Methods in Anthropology

There has been a lively discussion, in *Nature*[1] and elsewhere[2], on the classification of recent fossil finds in South Africa. Prof. S. Zuckerman has rightly stressed the need for basing such decisions on statistical tests. But his findings have been at odds with those based on classical comparisons; so that anthropologists must now be in doubt whether their science has, indeed, anything to learn from statistics.

This unhappy result can be traced to the piecemeal tests which have hitherto been used. A bone or a tooth is a unit; it is not a discrete assembly of independent measurements. To compare its single variates one by one, as Ashton and Zuckerman have done[3], is both inconclusive and misleading. Inconclusive, because nothing is decided when it is shown that, say, the height of an incisor lies in the range of heights of gorilla incisors, and the breadth lies in the range of breadths of chimpanzee incisors—a state of affairs which may well be characteristic of a species different from both; and misleading, because tests based on dimensions which are correlated are themselves not independent, and little is gained by accumulating them.

The right statistical method must treat the set of variates as a single coherent matrix; and this is, in fact, the technique of multivariate analysis. Consider, for example, four measurements (in millimetres) of a lower milk canine: x_1 the height, x_2 the maximum anterior–posterior length of the upper half, x_3 the maximum breadth of the upper half, and x_4 the maximum anterior–posterior length at the level of the basal cingulum. Also consider the problem, in the first place, of discriminating between two species — say, chimpanzee and man. Then the measurements should be combined in a single discriminating function,

$$X = a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4, \qquad (1)$$

where the constants a_1, a_2, a_3, a_4 are to be calculated from the averages, the variations, and the correlations, of the measurements within both species.

The discriminant we obtain in this way, using the measurements of forty human and forty-four chimpanzee milk canines, is

$$X = x_1 - 7{\cdot}49x_2 + 2{\cdot}34x_3 + 4{\cdot}70x_4, \qquad (2)$$

and this has on the average the value

$$X = +\ 17{\cdot}6 \text{ for the chimpanzee,}$$

and has the average value

$$X = -\ 5{\cdot}0 \text{ for man.}$$

The standard deviation of X is 2·45; so that the range of X, taken at $2\frac{1}{4}$ times the standard deviation, is 6·1 on either side of the average.

In order to classify a tooth, which is supposed to be either a human or chimpanzee lower milk canine, x_1, x_2, x_3, x_4 are measured in millimetres, and the measurements inserted in the discriminant function (2) above. If the result lies between +23·7 and +11·5 the tooth is chimpanzee; if between +1·1 and −11·1 it is human. For all the eighty-four teeth the measurements of which we have had, this test is decisive. The supposition that a tooth belongs to one of these two groups is at least strengthened by the fact that its value of X falls into one of the two ranges.

As an application, we have calculated the value of the discriminant function given by (2) for the Kromdraai and the Taungs milk canines found in South Africa. The values are −2·6 and −7·9 respectively. They demonstrate conclusively that these teeth do not belong to the chimpanzee group. More than this, they fall precisely in the human range. It would be wrong on this ground alone to conclude positively that they are human teeth; for the measurements might, for example, be matched on an object which turns out to be a pebble or a fake. But within the limits of the present comparison, the statistical evidence is that these teeth belong to the human family.

These methods of discrimination need not be confined to a choice between two alternatives. The technique of multivariate analysis makes it possible to construct functions to discriminate at one time between a number of species, and we hope elsewhere to construct such functions for human, chimpanzee, gorilla and orang-utan teeth. These functions can, we believe, have an important place in biological classification, for which indeed they were first designed. They show that the methods of modern statistics are not alien to anthropology, but are capable of assessing a fossil or a limb as a unit, and not as a haphazard jumble of piecemeal measurements.

J. Bronowski
W. M. Long

Cleeve Hill,
Cheltenham.
Aug. 31.

[1] Zuckerman, S., *Nature*, **165**, 652; **166**, 158, 953 (1950). Le Gros Clark, W. E., *Nature*, **165**, 893; **166**, 791 (1950).
[2] Le Gros Clark, W. E., *Man*, **51**, 18 (1951). Zuckerman, S., *Man*, **51**, 20 (1951).
[3] Ashton, E. H., and Zuckerman, S., *Phil. Trans. Roy. Soc.*, B, 234, 471 and 485 (1950); *Man*, **51**, 23 (1951).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 5

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. W. V. Lewis: "Glacier Investigation by Tunnelling".

UNIVERSITY OF LONDON (at the London School of Economics and Political Science, Houghton Street, Aldwych, London, W.C.2), at 5 p.m.—Prof. W. J. M. Mackenzie: "Science in the Study of Administration".*

SOCIETY OF ENGINEERS (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. L. H. J. Hersch: "Oilfield Operations".

SOCIETY OF CHEMICAL INDUSTRY (joint meeting of the FOOD, AGRICULTURE and MICROBIOLOGY GROUPS and the LONDON SECTION, at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Dr. E. R. Dawson: "The Cultivation and Propagation of Baker's Yeast".

PHARMACEUTICAL SOCIETY (at 17 Bloomsbury Square, London, W.C.1., at 7.30 p.m.—Mr. H. G. Rolfe: "Pharmaceutical Industry in America".

Tuesday, November 6

CHADWICK PUBLIC LECTURE (in the Sir Edward Meyerstein Lecture Theatre, Westminster Medical School, 17 Horseferry Road, London, S.W.1), at 2.30 p.m.—Dr. A. T. Doig: "The Principles of Prevention of Industrial Diseases".*

SOCIETY OF CHEMICAL INDUSTRY, CROP PRODUCTION PANEL of the AGRICULTURE GROUP (in the Chemistry Lecture Theatre, Royal College of Science, South Kensington, London, S.W.7), at 2.30 p.m.—Symposium on "The Selective Toxicity of 2-4, D and MCPA in Wheat, Oats and Barley".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5 p.m.—Prof. J. M. Mackintosh: "Trends of Opinion about the Public Health, 1901-1951, 1, The New Age" (Heath Clark Lecture).* (Further Lectures on November 8, 13, 15 and 19.)

INSTITUTION OF CHEMICAL ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Prof. D. M. Newitt, F.R.S., and Mr. M. Coleman: "The Mechanism of the Drying of Solids with Special Reference to China Clay".

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "Measurements Involved in the Testing of Protective Equipment" (to be opened by Mr. H. S. Petch).

ROYAL ANTHROPOLOGICAL INSTITUTE (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Huxley Memorial Lecture.

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Dr. H. E. Rose: "The Measurement of Particle Size in Very Fine Powders".* (Further Lectures on November 13, 20 and 27.)

SHEFFIELD METALLURGICAL ASSOCIATION (at the Grand Hotel, Sheffield), at 7 p.m.—Mr. A. A. Smales: "Radio Chemistry as an Aid to the Analytical Chemist".

Wednesday, November 7

ASSOCIATION OF APPLIED BIOLOGISTS (in the Mining Lecture Theatre, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7), at 11 a.m.—Discussion on "Photography in Applied Biology".*

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Scientific Papers.

Thursday, November 8

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), 4.30 p.m.—Sir Charles Ellis, F.R.S.: "Science in the Coal Industry".

MINERALOGICAL SOCIETY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. T. Kilvington, Mr. F. J. M. Laver and Mr. H. Stanesby: "The London–Birmingham Television-Cable System".

TEXTILE INSTITUTE, YORKSHIRE SECTION (joint meeting with the WEST RIDING SECTION OF THE SOCIETY OF DYERS AND COLOURISTS, at the Great Northern Victoria Hotel, Bradford), at 7.15 p.m.—Dr. F. Happey: "Synthetic and Natural Polypeptides".

UNIVERSITY OF LONDON (at Wye College, Wye, Kent), at 8.15 p.m.—Dr. H. P. Donald: "Facts and Fallacies in Livestock Breeding".*

Friday, November 9

ROYAL SANITARY INSTITUTE (in the Guildhall, Cambridge), at 10 a.m.—Papers on "Three Approaches to Man's Welfare" (Mr. D. W. Bottom: "Improving the Environment"; Dr. C. G. Eastwood: "Caring for Body and Mind"; Prof. A. Leslie Banks: "Research and the Wider Issues").

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (at Charing Cross Hospital Medical School, Chandos Street, London, W.C.2), at 5 p.m.—Prof. E. Wolff: "Sex Differentiation in Vertebrates".*

INSTITUTION OF MECHANICAL ENGINEERS (joint meeting with the HYDRAULICS GROUP, at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Mr. G. A. Wauchope and Mr. H. P. Humphreys: "The Design of Large Pumping Installations for Low and Medium Heads".

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at the Literary and Philosophical Society, Newcastle-upon-Tyne), at 6.15 p.m.—Prof. J. F. Baker: "Shortcomings of Structural Analysis" (Andrew Laing Lecture).

INSTITUTE OF ECONOMIC ENGINEERING (at the George Hotel, Church Lane, Kingsbury, London, N.W.9), at 7 p.m.—Mr. Winston Rodgers: "Pre-determined Motion Times".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. C. D. Darlington, F.R.S.: "The Two Theories of Heredity".

Saturday, November 10

BIOCHEMICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 11.15 a.m.—Symposium on "Metabolism and Function of Nervous Tissue".

BRITISH PSYCHOLOGICAL SOCIETY (in the Eugenics Theatre, University College, Gower Street, London, W.C.1), at 2.30 p.m.—Dr. H. A. Imus: "Fundamental Research in Human Relations".

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Sir Harry Lindsay: "The Museum and Education".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT (with a degree in engineering or equivalent qualification) IN THE DEPARTMENT OF MECHANICAL AND CIVIL ENGINEERING—The Registrar, Technical College, Infirmary Road, Chesterfield, Derbyshire (November 10).

ASSISTANT (Grade B) FOR MECHANICAL ENGINEERING at the Swansea Technical College—The Director of Education, Education Department, The Guildhall, Swansea (November 10).

ASSISTANT (Grade B) IN INORGANIC CHEMISTRY at the Constantine Technical College—The Director of Education, Education Offices, Woodlands Road, Middlesbrough (November 10).

ASSISTANT EXPERIMENTAL OFFICERS (with a degree in engineering or physics, or equivalent) IN THE HORTICULTURAL DEPARTMENT—The Secretary, National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds (November 10).

DEMONSTRATOR IN CHEMISTRY—The Registrar, Technical College, Sunderland (November 10).

HEAD OF THE DEPARTMENT OF METALLURGY, a SENIOR LECTURER IN METALLURGY, and a LECTURER IN THE DEPARTMENT OF ENGINEERING, County Technical College, Wednesbury—The Director of Education, Department F.E., County Education Offices, Stafford (November 10).

LECTURER IN ELECTRONICS AND TELECOMMUNICATIONS, and a TEACHER OF MATHEMATICS, at the Coventry Technical College—The Director of Education, Council House, Coventry (November 10).

LECTURER IN MECHANICAL ENGINEERING, and an ASSISTANT LECTURER (Grade A) IN MECHANICAL ENGINEERING, at the South Shields Marine and Technical College—The Director of Education, Town Hall, South Shields (November 10).

PRINCIPAL OF THE BURY TECHNICAL INSTITUTE—The Director of Education, Education Offices, Bury (November 10).

SCIENTIFIC OFFICER (Ref. R/A) for research and development work on mechanical engineering problems, a SENIOR SCIENTIFIC OFFICER (Ref. R/C1) for development to prototype stage of mechanical mechanisms of an original nature, a SCIENTIFIC OFFICER (Ref. R/C2) for work on combustion and heat transfer problems, and a SCIENTIFIC OFFICER (Ref. A/T2) to work on engineering problems—The Secretary, National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds, quoting the appropriate Ref. No. (November 10).

TEACHER (honours graduate in chemistry) IN CHEMISTRY—The Principal, Harris Institute, Preston (November 10).

RESEARCH ASSISTANT IN THE DEPARTMENT OF GEOGRAPHY, to assist in a project of research in agricultural geography—The Secretary, University College, Gower Street, London, W.C.1 (November 12).

PHYSICIST or PHYSICAL CHEMIST (Scientist II) to take part in laboratory scale investigations into crushing, screening and briquetting of coal, at the Central Research Establishment, Stoke Orchard, Cheltenham—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/384 (November 14).

RESEARCH OFFICER (with honours degree in physics or physical chemistry) to carry out work on physical properties of gelatin gels and solutions—The Director, British Gelatine and Glue Research Association, 2a Dalmeny Road, London, N.7 (November 14).

ENGINEER AND MANAGER OF THE WATER COMPANY—The Engineer and Manager, Gas and Water Company, Hartlepool, endorsed 'Engineer and Manager' (November 15).

LECTURER IN MECHANICAL ENGINEERING—The Registrar, King's College, Newcastle-upon-Tyne (November 17).

ASSISTANT LECTURER IN GEOLOGY (with qualifications in palæontology)—The Registrars, The University, Manchester (November 24).

POSTGRADUATE STUDENTSHIP IN PHYSICS—The Registrar, University College, Leicester (November 24).

HEAD OF THE PHYSICS DEPARTMENT at the Radiotherapy Centre—The Secretary, War Memorial Hospital, Scunthorpe, Lincs. (November 26).

RESEARCH OFFICER (Physicist) IN THE DIVISION OF FOOD PRESERVATION AND TRANSPORT, Sydney—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 3609 (November 24).

WATER ENGINEER AND MANAGER OF THE LEICESTER WATER UNDERTAKING—The Town Clerk, Town Hall, Leicester, endorsed 'Water Engineer' (November 24).

ASSISTANT DIRECTOR PUBLIC HEALTH BACTERIOLOGICAL LABORATORY (University of Melbourne)—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (November 30).

HUGH WOOD MEMORIAL FELLOWSHIP IN MINING—The Registrar, The University, Leeds 2 (November 30).

LECTURERS (2, specialists in medical protozoology and medical entomology) IN PARASITOLOGY at the University of Malaya, Singapore —The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (November 30).

PROFESSOR OF PHILOSOPHY at the University of Natal, Pietermaritzburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (November 30).

SENIOR LECTURER IN SOCIOLOGY AND SOCIAL WORK at the University of Natal, Durban—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (November 30).

LECTURER IN MINING SUBJECTS, and a LECTURER IN SCIENCE, at the Wrexham Technical College—The Director of Education, Education Offices, Ruthin, Denbighshire (November 30).

RESEARCH ASSISTANT IN NUMERICAL ANALYSIS in the Department of Applied Mathematics—The Registrar, The University, Liverpool (December 1).

SENIOR LECTURER IN PHYSICAL CHEMISTRY in the University of Tasmania and Hobart Technical College—The Agent-General for Tasmania, 457 Strand, London, W.C.2, or the Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Hobart, December 1).

STATISTICIANS (5, main grade) in the Civil Service—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting No. 4093/51 (December 6).

RESEARCH ASSISTANT (graduate in physics) for laboratory work connected with Papermaking in the Department of Textile Chemistry —The Registrar, College of Technology, Manchester 1 (December 12).

PROFESSIONAL ENGINEERS in many Departments of the Civil Service for a wide variety of engineering duties—The Secretary, Civil Service Commission, Trinidad House, Old Burlington Street, London, W.1, quoting S.85/51 (December 31).

REGIUS PROFESSOR OF CIVIL ENGINEERING AND MECHANICS in the University of Glasgow—The Private Secretary to the Secretary of State for Scotland, St. Andrew's House, Edinburgh 1 (December 31).

CHIEF SOIL CONSERVATOR, and SOIL CONSERVATORS OR JUNIOR SOIL CONSERVATORS, to the Otago Catchment Board—The Secretary, Otago Catchment Board, P.O. Box 858, Dunedin, New Zealand (January 18).

LECTURER IN PIGMENTS in the Department of Colour Chemistry and Dyeing—The Registrar, The University, Leeds 2 (January 19).

H.M. INSPECTORS—The SECRETARY (Inspectors' Section), Ministry of Education, Curzon Street, London, W.1 (January 31).

POSTGRADUATE FELLOWSHIPS (34) for research in pure chemistry and physics tenable in the National Research Council Laboratories at Ottawa, and POSTGRADUATE FELLOWSHIPS (5) in biochemistry, microbiology and related fields tenable in the Prairie Regional Laboratory at the University of Saskatchewan, Saskatoon—The Secretary, Laboratories Awards Committee, National Research Council, Ottawa, Canada, or The Chief Scientific Liaison Officer, National Research Council of Canada, Africa House, Kingsway, London, W.C.2 (Ottawa, February 15).

ASSISTANT LECTURER IN MATHEMATICS—The Registrar, The University, Nottingham.

CHEMICAL ENGINEER for investigations on various aspects of whiting manufacture, including drying processes, classification of powders by wet and dry processes, and general handling of suspensions and powders—The Director of Research, Research Council of the British Whiting Federation, 245 Ampthill Road, Bedford.

CHEMIST, general or analytical (with a good honours degree in chemistry, a sound knowledge of analytical chemistry and research and administrative experience), a RUBBER TECHNOLOGIST (with a wide experience in rubber technology and some experience of research and development work), and a COLLOID CHEMIST (with a good honours degree and research experience in surface or colloid chemistry) to undertake fundamental research on natural latex, at the Rubber Research Institute of Malaya, Kuala Lumpur—The Secretary, London Advisory Committee for Rubber Research (Ceylon and Malaya), Imperial Institute, South Kensington, London, S.W.7.

CHEMIST at Risley, to advise plant design engineers on the metallurgical aspect of their work, etc., and a CHEMIST at Springfields Factory, Salwick, Preston, to supervise the work of a team engaged on the development of powder metallurgy processes—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, stating post applied for.

CHEMISTS (Principal Scientific Officer grade) (with a first- or second-class honours degree or equivalent in chemistry, with many years responsible research experience in modern methods of analysis of inorganic materials, including microchemical methods) at a Ministry of Supply research and development establishment near London—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.64C/51A.

CHEMISTS (Scientific Officer grade) at the Ministry of Supply factory at Capenhurst, Chester, for research into the detailed behaviour of inorganic systems and their surfaces (the work may involve electronic diffraction and X-Ray techniques as well as conventional chemical qualification)—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs.

CURATOR (with an honours degree in archæology, with some anthropological training) IN THE DEPARTMENT OF MUSEUMS, Malaya—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. No. 2744C/51.

ENGINEER (with degree or equivalent in engineering) to assist in development work connected with concrete vibrators, etc., at research laboratories of the Cement and Concrete Association, Wexham Springs, Slough—The Secretary, British Cast Concrete Federation, 17 Amherst Road, Ealing, London, W.13.

EXECUTIVE ENGINEER IN THE PUBLIC WORKS DEPARTMENT, Northern Rhodesia, for general civil engineering duties—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27322/115.

EXPERIMENTAL OFFICER at Springfields Factory, Salwick, Preston, to assist in large-scale development work on processes or reduction of metals and treatment of residues—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs.

EXPERIMENTAL OFFICERS at the Atomic Research Establishment, Harwell, for work in Physics, Electronics and Scientific Computing (Ref. A.309/51A/BA), and Chemistry (other than Organic Chemistry), Chemical Engineering and Metallurgy (Ref. F.777/51A/BA)—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No.

GRADUATE IN PHYSICS (with a bias towards engineering) to undertake research work in the unexplored field of glasshouse heating and ventilation—The Head of the Garden Research Department, John Innes Horticultural Institution, Bayfordbury, Hertford, Herts.

HEAD OF THE CHEMICAL ENGINEERING SECTION, and a PLANT PHYSIOLOGIST to direct and undertake fundamental biochemical investigations with a view to the ultimate development of mass culture techniques for the lesser known marine algæ of potential industrial value—The Secretary, Institute of Seaweed Research, Invereak, Midlothian.

PHYSICIST to carry out research on the performance of photographic lenses—(Applications), Technical Optics Section, Physics Department, Imperial College of Science and Technology, South Kensington, London, S.W.7.

PHYSICIST, and a PHYSICAL CHEMIST (with first- or second-class honours degree; some postgraduate experience is desirable)—The Director, British Paper and Board Industry Research Association, St. Winifred's Laboratories, Welcomes Road, Kenley, Surrey.

RESEARCH ASSISTANT (graduate in chemistry) IN THE DEPARTMENT OF CHEMICAL ENGINEERING AND APPLIED CHEMISTRY, to carry out investigations on ignition and flame propagation in gases—The Registrar, Imperial College of Science and Technology, South Kensington, London, S.W.7.

SENIOR PLANT PATHOLOGIST (Senior Principal Scientific Officer) at the West African Cocoa Research Institute, Gold Coast—The Under-Secretary of State, Colonial Office, Research Department, Sanctuary Buildings, Great Smith Street, London, S.W.1.

SENIOR PRINCIPAL SCIENTIFIC OFFICER (veterinary research) to undertake direction of protozoological, epidemiological and trypanosomiasis research, a SENIOR SCIENTIFIC OFFICER (veterinary research) to undertake research in animal trypanosomiasis, a SCIENTIFIC OFFICER (veterinary research) to undertake research in animal trypanosomiasis, a PROTOZOOLOGIST to undertake studies of tyrpanosomes and trypanosomiasis, and MEDICAL RESEARCH OFFICERS (2) for research into human trypanosomiasis and epidemiology, at the Central Trypanosomiasis Institute, Sukulu, Uganda—The Under-Secretary of State, Research Department, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1.

TEACHER (professorial grade) OF PHARMACOLOGY at the Lady Hardinge Medical College, New Delhi—The Secretary (Division 5A), Ministry of Health, Savile Row, London, W.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Air Ministry: Meteorological Office. Professional Notes No. 103: Stratus Cloud near the East Coast of Great Britain. By G. A. Bull. (M.O. 524c.) Pp. 16. 6*d*. net. Professional Notes No. 104: Meteorological Aspects of Turbulence affecting Aircraft at High Altitude. By J. K. Bannon. (M.O. 524d.) Pp. 16. 6*d*. net. (London: H.M. Stationery Office, 1951.) [228

General Register Office. The Registrar General's Quarterly Return for England and Wales: Births, Deaths and Marriages, Infectious Diseases, Weather, Survey of Sickness, Population Estimates, Quarter ended 31st March 1951. Pp. 40. (London: H.M. Stationery Office, 1951.) 1*s*. 6*d*. net. [228

Supplement No. 5 (1951) to British Standard 204: 1943, Glossary of Piezo-electric Terms. Pp. 6. (London: British Standards Institution, 1951.) 1*s*. net. [228

Recommended Designs for Metal Arc Welded Mild Steel Building Structures: Beam and Column Connections. (T.28.) Pp. 16. (London: British Welding Research Association, 1951.) 2*s*. 6*d*. [238

Other Countries

Fieldiana. Botany, Vol. 28, No. 1: Contributions to the Flora of Venezuela. By Julian A. Steyermark and collaborators. Pp. 242. (Chicago: Chicago Natural History Museum, 1951.) 4 dollars. [208

Research and Scholarship in the University of Sydney: a Short Record of Original Work done during 1946 and 1947. Pp. 120. (Sydney: Australasian Medical Publishing Co., Ltd., 1951.) [208

Northern Rhodesia: Water Development and Irrigation Department. Annual Report for the Year 1950. Pp. 9. (Lusaka: Government Printer, 1951.) 1*s*. [208

Provisional Reports of Observations of the Partial Eclipse of the Sun on September 12, 1950. Pp. iv+83. (Tokyo: Science Council of Japan, 1951.) [208

South Australia: Institute of Medical and Veterinary Science. Twelfth Annual Report of the Council, July 1949–June 1950. Pp. 45. (Adelaide: Government Printer, 1951.) [208

Acta Medica Scandinavica. Supplementum 261: Renal Regulation of the Extracellular Fluid, II. Renal Physiology in Electrolyte Subtraction. By D. A. Denton, Victor Wynn, I. R. McDonald and Shirley Simon. Pp. v+202. (Melbourne: Department of Physiology, The University, 1951.) [208